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PROCEEDINGS

OF THE

TWENTY-FOURTH ANNUAL

CONVENTION

OF THE

American Water Works Association

HELD AT

ST. LOUIS, MO.

JUNE 6, 7, 8, 9, 10, 11, 1904.

PUBLISHED BY THE SECRETARY

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

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MORRIS R. SHERRERD, President.

PROCEEDINGS
OF THE
TWENTY-FOURTH ANNUAL CONVENTION
OF THE
AMERICAN WATER WORKS ASSOCIATION
HELD AT
HOTEL JEFFERSON, ST. LOUIS, MO.
JUNE 6, 7, 8, 9 1904.

FIRST DAY—EVENING SESSION.

MONDAY, JUNE 6. 1904.

At 8:30 P. M., on June 6, 1904, in the magnificent rotunda of the Hotel Jefferson, St. Louis, Mo., the delegates and visitors to the Twenty-fourth Annual Convention of the American Water Works Association, with their ladies, assembled as the guests at a reception tendered by the local Entertainment Committee.

The occasion was notable, not only as the inaugural function of the Convention, but as being held in the metropolis of the grand State of Missouri during the progress of the World's Fair of the Louisiana Purchase Exposition. It was matter of congratulation that at such a time such a large number of the ladies were in attendance, and their bright faces and pleasing toilets, together with enlivening music and other appropriate accessories, made the evening a most auspicious prelude to the regular business of the Convention of the subsequent days.

Mayor Wells, who was to deliver the Address of Welcome, was detained at the Exposition, and it was nearly a quarter past ten when he finally arrived upon the scene, and the company was requested to come to order by

Fourth Vice-President Mr. Benjamin C. Adkins of St. Louis, also Chairman of the local Entertainment Committee.

MR. ADKINS said:

Ladies and Gentlemen: The Twenty-fourth Annual Convention of the American Water Works Association will now come to order.

I have the distinguished honor of introducing to you the Honorable Rolla Wells, Mayor of the City of St. Louis, who is here to welcome our Delegates and Guests.

ADDRESS OF WELCOME BY HON. ROLLA WELLS, MAYOR.

Mr. President, Ladies and Gentlemen: I was in this rotunda but a moment when I realized, after seeing the bright and happy faces of the ladies and gentlemen present, what a misfortune had been mine this evening in not being able to be present with you earlier in your session.

But I assure you, while my desire was to be here, yet the numerous duties and obligations that the very strenuous life that the Universal Exposition in this city has brought down upon our heads and shoulders and forced into our stomachs, made it impossible for me to be with you earlier.

I do not know that I can say anything to you that will particularly interest you.

You, gentlemen, are professional men: you are engineers of a profession that means much to a municipality, to a city, to a congregation of large numbers of people.

You are engineers whose work, the result of whose effort, possibly means the health and the happiness of entire communities. You have a responsible duty in life in the providing of that which is most essential to human life, namely, a pure and sparkling water. (Applause.)

My experience within the last six weeks has been that water is very uncommon. (Laughter.) Champagne most common.

Ladies and gentlemen, I am glad of this opportunity as the Executive of this, the city of St. Louis, to welcome you to our municipality. You are a number among thousands of others who during this festival time, this festal period, are congregating within the limits of this city from all nations, from every quarter of the globe; and well may the people from all over this great country, as well as from far Asia, India and elsewhere, congregate at this time within the limits of the city of St. Louis, for the reason that the city of St. Louis, through the enterprise of its citizens, I am safe in saying, has provided for the entire world an Exposition that never has been surpassed. (Applause.)

Twenty-eight years ago the city of Philadelphia inaugurated expositions, commemorating then the one hundredth anniversary of the Independence of the United States. Great had been the growth even then of this country. During the century then ended the population of these United States had grown to forty-three millions, and from thirteen to thirty-seven States; and now in this year of 1904 the city of St. Louis holds the high distinction of being host to over eighty millions of the United States peoples alone, and of having provided an Exposition to which I have just referred, which cannot help but prove an educational feature for the enlightenment of all who may have the good fortune to inspect it.

In conclusion, I want to take this favorable opportunity to say that as the Executive of this city I am well pleased with the manner in which it is constituted from an executive and legislative standpoint. We have our organizations; we have our departments, each and every one of them essential to the economic management of the city, essential to the happiness of our people; and without any flattery, I take pleasure in stating to you engineers, hydraulic and civil engineers, that of all these departments none has afforded me, as the Executive, more satisfaction in its operation, none through its intelligent manipulation and management has proven of greater benefit to the population of this city than that department known as the Water Department. (Prolonged applause.)

It is so ably, so conscientiously managed by that faithful public servant, as we are all public servants if we are honest in the administration of our respective duties, none have given more satisfaction than that public servant, that public official, the Honorable Water Commissioner, your host to-night, Mr. Adkins. (Applause and cries of "Good boy, Adkins!")

MR. ADKINS: *Ladies and Gentlemen:* The honor that Mayor Wells has bestowed upon me by his remarks just made simply overwhelms me. I certainly appreciate his expressions, and also the honor that all my friends desire to show me. I have tried to fulfill the promise that I made to Mr. Wells when I took my office. He retires before I do, but I hope that when I retire I shall merit the approval that he evidenced in appointing me. In the discharge of my duties I have felt that I represented Mr. Wells and also the people of the city of St. Louis, and I not only thank Mr. Wells, but the people as well, for the trust and confidence reposed in me, and I hope that my acts will merit their approval also during the remainder of my term of office. (Applause.)

I now have the pleasure of introducing to you Mr. Morris R. Sherrerd, the First Vice-President of the American Water Works Association. (Applause.)

While I always like to hear Mr. Sherrerd speak, still he does not always like to speak, except when the occasion demands it, as it does to-night. Our distinguished colleague, President Case, notified us by telegraph that the Doctor forbade him coming to the city of St. Louis; and it is well that we have a very able lieutenant in Mr. Sherrerd to preside in his stead, and who will respond to the Mayor. (Applause.)

RESPONSE BY FIRST VICE-PRESIDENT MORRIS R. SHERRERD.

ENGINEER AND SUPT. WATER WORKS, NEWARK, N. J.

Mr. Mayor, Ladies and Gentlemen and Members of the A. W. W. A.:

In assuming the honor of responding for the Association to the kind and grateful welcome of Mayor Wells, I regret, for myself, but more particularly for the Association and this assembly, that the illness of our President, Mr. Case, has prevented his being with us at this convention to greet you, which privilege I know would have been very dear to his heart.

We thank you, and I thank you in the name of the Association, Mr. Mayor and our kind friends in St. Louis, for your expression of goodwill and esteem. We shall endeavor to take advantage of the instruction and pleasure your handsome and world-famed city offers, and we hope you may also gain some advantages as a city in the results of our deliberation, as you have already done from the work of one of our honored members, our vice-president, Mr. Adkins. (Applause.)

We are especially glad to meet in St. Louis at this time, not only because it is conducting the greatest fair the world has ever known, but because it was here that our Association was founded in 1881; and this is our twenty-fourth annual convention. Almost a quarter of a century has since elapsed. Then there were twenty members, representing a few states, and it was at first intended to confine the Association to private water companies in the Middle West. Now we number 331 active, 62 associate, and 7 honorary members, representing both private and public water works in every state in the union, and throughout the entire continent.

Of the original twenty charter members some have passed out of the water works field, but five still retain their membership in the Association; two of these, Mr.

Sylvester Watts and Mr. M. L Holman, being residents of St. Louis, and honorary members of this Association. I also understand that one other of the charter members, Mr. Ira A. Holly, now of New York City, is in attendance at this meeting.

We believe that the importance of the work of this Association demands our banding together for mutual information and support. Particularly is the water question, the procuring of abundant and pure water supplies, one of very great necessity in this age of rapidly developing cities. The trend of modern construction, the immense skyscrapers that are now going up requiring special water facilities and fire protection, and similar matters, demand the most careful consideration, and we appreciate, Mr. Mayor, the fact that such men as yourself take the trouble to come and welcome an organization of this kind.

I think it would be appropriate on account of the absence of President Case that our Past President, Mr. Campbell, favor us with a few remarks on this occasion. (Applause.)

RESPONSE BY PAST PRESIDENT C. H. CAMPBELL, SUPERINTENDENT WATER WORKS, CHARLOTTE, N. C.

Mr. Mayor, Mr. President, Ladies and Gentlemen:

In order to emphasize or illustrate a point in connection with this selection of myself as one of your speakers this evening, I am reminded of a story. There was a professor of one of our leading colleges who thought to entertain the senior class at his home one evening. He had the boys all down there and ushered them into a large and elegantly furnished room, ornamented with bric-a-brac, such as tomahawks, shields, bows and arrows, old guns and sabres. Suspended under the massive mantelpiece was a very beautiful sabre, elegantly engraved. The boys walked around the room looking at the curiosities, and finally one of them said: "Professor, this is a very handsome sabre."

"Yes, it is very fine," said the professor, and he took it down and unsheathed it, adding, "Boys, I never draw that sword but I think of the first time I drew it." Some one asked, "Why, Professor, where did you draw that sword?" The professor replied, "I drew it in a raffle."

So my friends, if you are disappointed in any remarks that I may make with regard to the American Water Works Association you may know that Brother Sherrerd here drew your speaker in a raffle.

I wish to say, Mr. Mayor, that at Detroit it was my pleasure to advocate St. Louis on the floor of our convention as the point to be selected for our next meeting. I stated there that if we didn't have a good time in St. Louis it would be Ben Adkins' fault, and that if he had a fault I had never heard of it!

We find that you are meeting all of our expectations. It is hardly worth while for me to speak of the magnitude of the work that your people are performing here. It is matter of common knowledge throughout this country by every one who keeps up with the times—and all Americans in these days read and know what is going on. As we look around the cornice of this magnificent rotunda, we see St. Louis pictured there. There are the emigrant wagons in which our forefathers came across the wilds and deserts of this country, braving their dangers and withstanding the poisoned arrows of the vicious savages. As the result of all their sacrifices and privations, here we find the culmination in this magnificent exposition, the work of this great and glorious city of the West.

And on behalf of the American Water Works Association, whom you have highly complimented this evening by your appreciation of these professional gentlemen and their works, I want to say that the men are the smallest part of our Association. (Applause.) The flower of the Association you see also here, the ladies, decorating this occasion. They are plucked from our homes broadcast over the

United States, in order that for the time being we might ornament your city by transplanting our fairest flowers here.

Vice-president Sherrerd: I think we are entitled, ladies and gentlemen, to a few remarks from our secretary, Mr. Diven.

Secretary Diven: Mr. Mayor, Ladies and Gentlemen: I supposed you all knew that the secretary's business was to work, not to talk. It is my business to make other people talk by providing something for them to talk about. The result sometimes is that we have a book like this (referring to the last Annual Report of Proceedings), which your secretary sat up nights poring over and then had to hustle around to pay the printer's bill. About that time I thought I had perhaps a little overdone the matter. Here is the report of the first convention, which was held in St. Louis twenty-four years ago. We have progressed to this (referring again to the last Annual Report, a book of over 725 pages), and when we shall have left St. Louis this time there is no telling how large the report will be. (Applause.)

But we are young yet. Only three years ago we passed our majority, and now we are getting to an age where we are doing real work. Your vice-president stated that we now have 331 active members. Twenty-five years from now, when we come back here again, we are going to have at least 2,000 active members and have them all here. (Applause.)

But, as I said, it is my business to do that which will make others talk, and I am going to save all my energies so that I will have something to put in the next proceedings. (Applause.)

After some minor announcements by Chairman Adkins, and a request by Vice-President Sherrerd to be promptly on hand at the morning session, Tuesday, the formal exercises of the evening were now concluded.

SECOND DAY—MORNING SESSION.

TUESDAY, JUNE 7, 1904.

The Convention met pursuant to adjournment, First Vice-President Sherrerd in the chair.

VICE-PRESIDENT SHERRERD: I regret to be obliged to announce, as most of you who were present last night know, that President Case is too ill to attend the convention. Both Secretary Diven and myself have been endeavoring to induce Mr. Case to come on, even if but for one day during the session. Mr. Case, however, wrote the secretary, again stating that the doctor refused to allow him to come. I am glad to be able to say that I had a telegram from President Case yesterday in which he advised that he was better, but still under orders from his physician not to leave home.

Without objection, the next order of business, roll call by the Secretary, was omitted; and, on motion of Mr. Rosamond, the reading of minutes of last meeting was dispensed with, and there being no objection, the same were approved as heretofore published and distributed to the members.

VICE-PRESIDENT SHERRERD: The next order of business is reading of applications for membership. I take pleasure in announcing that there are 54 applications for active membership and 14 for associate. (Applause.)

Secretary Diven read the following applications for membership:

ACTIVE MEMBERS.

Frank Talbott, Superintendent, etc., Water Works, Danville, Va.

D. H. Clark, Clerk, City Water Works, Ironton, Ohio.

W. P. Fitch, Superintendent Water Department, Mason City, Iowa.

Edward Elbert, Water Commissioner, Reading, Pa.

Walter L. Lefavor, Manager Water Works, Springfield, Mo.

Robert H. McGrath, member Board Water Works Trustees, Lafayette, Ind.

C. L. Alderman, Manager Big Springs Water Co., Big Springs, Texas.

Charles F. Brotherton, Manager Water Co., Ashtabula, Ohio.

John F. Gallagher, Superintendent Water Works, Kingston, N. Y.

August F. Eggers. Water Commissioner, Newark, N. J.

George Houston, Water Commissioner, Kalamazoo, Mich.

J. L. Ludlow, Consulting Engineer (Municipal practice), Salem, N. C.

John E. Kemp, Superintendent Water Department, Kewanee, Ill.

Ernest B. Bain, Superintendent Water Works Co., Raleigh, N. C.

A. W. Hardy, Inspector and Hydraulic Engineer, Chicago, Ill.

J. W. Hall, Manager Stockton Water Co., Stockton, Cal.

W. R. Conard, Inspector of Materials, Burlington, N. J.

I. M. Higbee, Superintendent and Hydraulic Engineer, Lewisburg, Pa.

H. V. Gates, President Water Works Co., Hillsboro, Oregon.

William H. Humphreys, Engineer, Manager and Secretary York Water Works Co., York, Eng.

Sidney C. Robinson, Manager Water Works, Walkerville, Ontario.

Louis M. Jefferis, Constructing Engineer. E. St. Louis, Ill.

F. Conlin. Water Commissioner, Bethlehem, Pa.

Charles L. Heisler, President Heisler Pumping Engine Co., Pittsburg, Pa.

Emory A. Ellsworth, Hydraulic Engineer, Holyoke, Mass.

W. B. Getchell, City Engineer, Augusta, Me.

Adolphe J. King. General Manager Water Works, Alamogordo, N. M.

Charles W. Cobb, Superintendent Water Works, Kankakee, Ill.

Karl C. Kastberg, City Engineer and Superintendent City Water Works, Boone, Iowa.

H. L. Calhoun. Secretary Water Works, Ft. Worth, Texas.

Allen W. Cuddeback, Engineer and Superintendent Passaic Water Co., Paterson, N. J.

J. D. Landes, Secretary-Treasurer Water Supply Co., Canapoharie, N. Y.; residence, Mechanicsburg, Pa.

Emmett MacDonald, Superintendent Water & Light Co., Lincoln, Ill.

Thomas W. Gannon, Superintendent Water Works, Cairo, Ill.

J. W. Griffin, Superintendent Water Works, Arlington, N. J.

Charles E. Dennis, Superintendent Water Works, Watkins, N. Y.

H. D. Hibbeler, Secretary-Treasurer, Washington, Mo.

Theodore A. Leisen, Chief Engineer Water Department, Wilmington, Del.

Lewis P. Andrews, President Water & Light Co., Sedalia, Mo.

J. A. Miller, Superintendent Water Co., Louisiana, Mo.

Ralph H. Garrison, Superintendent Public Works, Vineland, N. J.

Henry M. Aiken, Resident Manager Water Co., Knoxville, Tenn.

F. S. Cook, Engineer Aqueduct Commission, Yonkers, N. Y.

George J. Hutton, Water Commissioner, Harrisburg, Pa.

George G. Kennedy, Superintendent Water Department, Harrisburg, Pa.

John F. Way, Superintendent Water, Light & Power Co., Watertown, S. Dak.

Eugene Carroll, Superintendent Butte Water Co., Butte, Montana.

T. T. McLeod, Manager Water Co., Missoula, Montana.

George F. Whitney, M.D., Biologist, East Orange, N. J.

C. L. Fellows, Deputy City Engineer, Toronto, Canada.

Nathan Strause, President Water Works, Ashland, Ohio.

E. E. Wall, Assistant Engineer Water Department, St. Louis, Mo.

W. E. Rolfe, Water Department, St. Louis, Mo.

W. A. Patton, President and Manager Water Works, Catlettsburg, Ky.

ASSOCIATE MEMBERS.

S. R. Dresser, Patentee and Manufacturer, Bradford, Pa.

A. R. Whitall, President Hydro-Carbon Mfg. Co., Denver, Colo.

L. B. Yeiser, Salesman for the Sanitary Co., Cleveland, Ohio.

National Brass & Metal Co., Harry N. Fowler Representative, Minneapolis, Minn.

T. A. Gillespie, President T. A. Gillespie Co., Orange, N. J.

The William Tod Co., Mfrs., High Duty Pumping Engines, Youngstown, Ohio.

The Westinghouse Machine Co., E. E. Keller, Vice-President, East Pittsburg, Pa.

Lyndon E. Adams, General Sales Manager, Garlock Packing Co., Philadelphia, Pa.

Charles R. Day, Sales Agent, The Midvale Steel Co., Philadelphia, Pa.

M. A. Corbett. Columbus Meter Seal Mfg. Co., Columbus, Ohio.

Jackson Filter Mfg. Co., Powell Jackson, President, St. Louis, Mo.

Glauber Brass Mfg. Co., Cleveland, Ohio.

Hoge & Swift. Manufacturers Agents, Portland, Ore.

Water Department, City of Great Falls, Montana (Municipal Plant.)

On motion of Mr. Tucker, the Secretary was directed to cast the ballot of the Association for the election of the foregoing to membership; and the Secretary having so done, their election was duly announced by the chair.

In the absence of President Case, his annual address was read by Vice-president Sherrerd, viz.:

ADDRESS BY THE PRESIDENT, MR. L. N. CASE, MANAGER WATER AND LIGHT DEPARTMENT, DULUTH, MINN.

To the Members of the American Water Works Association.

Gentlemen: As from time to time during the year that has gone, I have contemplated the preparation of this address to you, some very unusual and unexpected thoughts came into my mind; thoughts that were at first somewhat depressing to my egotism, but which became after further reflection more satisfactory, and even amusing.

"Confession is good for the soul" is a wise old proverb. I have also found by experience that it is pleasant to tell the truth occasionally. It is not best or wise to tell it always—it isn't always told. In fact, as Douglas Jerold says, "In this world the truth must wait—she's used to it."

I wish to confess, first, that as I returned one year ago to my home from the convention in Detroit, I was considerably swelled up with pride, which certainly was pardonable, considering the great honor that had been conferred upon me. I said to myself "You're it. You're the whole thing!"

I recall an experience in my army life as somewhat illustrative of certain conditions of thought and action, that occurred to me early in my administration.

A quartermaster sergeant of my regiment, who was totally unacquainted with army tactics and ignorant of drill duty, had been promoted to a lieutenancy and assigned to the command of a company. I was the adjutant of the regiment at that time, and during the first morning of regimental drill after his assignment I took command of his company at his request, he accompanying, and under my instructions, carefully observing the commands given. In the afternoon at the assembly call for dress parade, curious to know how he would conduct himself, I stood watching the formation of his company. Promptly at the call the orderly sergeant formed line in double rank, counted off from right to left, right dressed, presented arms, and then saluting, reported, "Lieutenant, the company is formed."

The lieutenant stood nervously observing every movement, looked embarrassed upon receiving the report—hesitated—stammered—and finally blustered: "Boys, I guess you'll have to march off endways as you did this morning!"

I returned to my home, as I observed before, not only swelled up with pride, but with my mind agitated with various schemes and plans by which I was to render *my* year the equal, if not the superior, of all others.

I prepared a circular early in the year, as you are aware, which was distributed through the secretary's office, certain portions of which, as I contemplated them later on, particularly its reference to the large increase of membership obtained by the previous administration, forcibly recalls the memory of the command given by the lieutenant: "March off endways, as you did this morning."

As time passed on, however, and the months grew, I saw our secretary taking such steps as were practicable and wise to make the year a successful and profitable one, sometimes adopting a suggestion of mine, and sometimes quietly turning them down, until it finally dawned upon me that a president was but a figurehead after all, and that it would be wisest and best not to interfere very much with the man at the helm; that he who had been over the course before and understood the flow of the currents, the channel and the soundings, was perfectly competent to guide the ship of state with but little advice from me.

As I thus philosophically summed up this feature of our organization, and fully realized that at best a president is but for a day, and that the man upon whom the welfare of our Association and the success of our conventions really depend, and upon whose shoulders rests the responsibility of its operations, is the man whom we wisely elect year after year as our secretary, and who, while watching each president "strut his one brief hour," smilingly murmurs to himself those touching lines of Tennyson's Brook,—

"For men may come and men may go,
But I go on forever."

I will content myself, therefore, in rejoicing with you, gentlemen, that the year has brought with it additional causes for congratulation to ourselves as an Association, and that this meeting, particularly because of the great event coincident therewith, must be of unusual character and one long to be remembered.

In view of the conditions and circumstances attending this convention, there has been a strong feeling in the minds of many that the very attractive influences surrounding us will have a tendency to cause us to neglect the business that is here to come before the Association.

Notwithstanding the fact that, at our meeting in Detroit we committed ourselves in unmistakable terms to a loyalty to the interests of this convention, and to the determination to submit to its requirements as to attendance at its meetings and to a faithful transaction of its business, yet, in consideration of the great temptation that will assail us one and all, I ask you to refresh your memories, both as to the fears expressed at Detroit, and the strong, earnest and determined animus that characterized the sentiments of a large majority of those present who advocated assembling in St. Louis at this time.

Knowing, as we do, the character and minds of those who expressed the fear that our meetings would be neglected, we also know that nothing can afford them a greater gratification than to find that their fears are groundless, and that this convention will lack none of the zeal and earnest efforts that have invariably characterized the meetings of the Association.

We meet together, gentlemen, as I stated in my reply to the welcoming address at Detroit, for the purpose of learning, one from the other, that which will enable us to best conserve the interests of the communities in which we live. It is not my purpose, in this connection, to occupy very much of the valuable time of this convention in the presentation of thoughts and ideas that come to me through long experience regarding the disposition of men and material that is best calculated to produce successful results in the operation of a water plant.

I will simply say to you: that whatever success I may have attained in my many years of management has been due almost entirely to an accumulated knowledge of little things, a thorough familiarity with details, a systematic arrangement of operations, and a kindly regard for the welfare of my subordinates.

These qualifications, coupled with an earnest effort to be fair and just and without discriminations in all your dealings with the people, will tend to accomplish more in direct results to yourselves and the interests you serve than any other course of action however capable or learned or scholarly.

I congratulate the Association particularly upon its practical solution of the question of electrolysis. Thanks to the distinguished services of Mr. Maury, and to the vast fund of information received from A. Larsen, A. A. Knudson, C. E. Rowe and others, we may safely feel that the disease has been correctly diagnosed and the remedy prepared ready to administer. The question now seems to be: "Can we prevail upon the patient to take his medicine?"

I congratulate the Association also upon the decision obtained by the City of Duluth in the Supreme Court of the State of Minnesota, establishing the right of the purveyor to place meters upon consumption of water at its own discretion; this right carrying with it, of course, the provision that its meter rates are equitable.

I have placed in the hands of the Secretary copies of the decision of the court and of the masterly presentation of the case as contained in the brief of our city attorney, Oscar Mitchell. I recommend that these documents be referred to the Committee on Publication to select such portions thereof as it may seem best to them for publication in our proceedings.

The result of calling upon the members for an expression of opinion as to the manner of conducting this convention, whether to devote our continual attention to the transaction of its business until its completion, or to hold half day sessions, is as follows:

One hundred and fifty-four cards were received in return to our question, 61 voting for a continual session and 93 voting for half day sessions. In conformity therewith, your Executive Committee decided upon half day sessions, which decision is subject to your approval. If, however, it may appear best in the minds of the members assembled here in convention to reverse the said decision. I hold that it is clearly within their rights so to do.

In closing my address, I desire to refer again to the great honor that this Association confers upon the member whom it elects as its president.

Without being able to only partially understand by what happy combination of circumstances I attained it, whether as the result of the guiding hand of a special Providence, or because of the fraternity and sense of justice existing in the hearts and minds of the members of this Association, or whatever the primary cause may have been, it is an honor that I appreciate most keenly and desire, in a way, to perpetuate.

To that end I recommend that a committee of three be appointed to select a design for a past president's badge, and that this committee be empowered to furnish this design to the past presidents of the Association, together with a copy of such resolution as you may deem proper to frame, authorizing them to provide themselves with, and to wear upon all suitable occasions, this badge of honor.

I have made no special mention in my address of our Associate Membership, nor do I desire to, because in my heart and mind is treasured, and will ever be, inseparable and undivided, the membership as a whole, Active and Associate, of this splendid organization.

To you, one and all, I tender my grateful acknowledgments.

VICE-PRESIDENT SHERRERD: The President's address contains a recommendation which, it seems to me, might be acted upon at this time. What is your pleasure?

On motion of Mr. Nourse, the chair was authorized to appoint a committee of three to design an appropriate badge and formulate provisions for its use.

The chair later announced the following as such committee, viz.: L. N. Case, T. R. Cook and E. L. Peene.

On motion of Mr. Gwinn, the Secretary was directed to send a telegram of greeting to President Case expressing regret because of his inability to be present, and sympathy with him in his sickness

In accordance with the usual custom, President Case's address was referred to the Executive Committee.

By direction of the chair, Secretary Diven read the report of th Executive Committee, viz.:

REPORT OF THE EXECUTIVE COMMITTEE.

ST. LOUIS, MO., June 6, 1904.

To the Members of the American Water Works Association.

Gentlemen: Your committee recommends that all members who were three or more years in arrears at the beginning of the fiscal year—April 15th ultimo—and who at that time received or were served with sixty days' notice, as provided by the constitution, be suspended, if their dues are not paid by the 15th inst., the expiration of the sixty days notice.

We recommend that the Secretary be authorized to have one thousand five hundred (1,500) copies of the proceedings of the twenty-fourth annual convention printed; and that he be authorized to distribute free to water works officials not now members of the Association, but who, in his judgment, might be induced to join, three to four hundred copies, for the purpose of advertising the Association and securing new members.

Your committee have examined such papers as were not presented in time for examination by the Publication Committee, and recommend that they be so far accepted as to be read before the convention, and then referred to the Publication Committee.

Your committee have carefully examined the revised constitution as presented by the committee appointed at the last annual convention to revise the same, and, with such alterations, additions and corrections as we have suggested to the committee, and which have been incorporated in their report, recommend it to the convention for adoption, to take the place of the present constitution.

Your committee recommend that the report of the special committee appointed to audit the accounts of the late Secretary, Mr. Peter Milne, be accepted, the committee discharged and that further settlement with his estate be left with the finance committee.

Your committee have fixed the salary of the Secretary-Treasurer at the same amount as for the preceding year.

Your committee have received a communication from a prominent manufacturer of fire hydrants asking that this Association appoint a committee to confer and act with committees from other societies and associations, with a view to securing uniform hose couplings and hydrant connections throughout the country; and recommend that the matter be referred to the Insurance Committee.

Respectfully submitted,
M. R. SHERRERD, *Chairman.*
THOMAS H. BENNETT,
CHAS. E. ROWE,
H. E. KEELER,
C. H. CAMPBELL,
A. A. TUCKER,
J. M. DIVEN, *Secretary,*
Committee.

On motion, the foregoing report was received and accepted and ordered to be printed in the proceedings.

Mr. H. E. Keeler, chairman of Finance Committee, submitted their report, as follows:

REPORT OF FINANCE COMMITTEE.

To the Members of the American Water Works Association.

Gentlemen: Your Finance Committee would report that they have carefully examined the books, accounts, vouchers and other papers in connection with the finances of the Association and the report of the Secretary-Treasurer and are pleased to find them in good condition and correct as per his statement.

Respectfully submitted,
H. E. KEELER,
R. J. THOMAS,
GEO. J. DUNBAUGH,
Committee.

On motion of Mr. Rosamond, the foregoing was adopted and ordered printed in the proceedings.

The Secretary submitted his report, as follows:

REPORT OF THE SECRETARY-TREASURER.

To the Members of the American Water Works Association.

Gentlemen: I have the honor herewith to submit the twenty-fourth annual report of the Secretary-Treasurer of the American Water Works Association.

At the close of the year 1902-3 the roll of members stood as follows, viz.:

Honorary Members	7
Active Members	288
Associate Members	54
Total	349

Of this number two active members died, six active and one associate members resigned, and thirteen active and one associate were dropped for non-payment of dues, leaving the list as follows, viz.:

Active Members	267
Associate Members	53
Honorary Members	7
Total	327

At the Detroit convention there were elected:

Active Members	69
Associate Members	11
Total	80

Making the roll at the beginning of this year:

Active Members	336
Associate Members	64
Honorary	7
Total	407

The losses during the year are as follows, viz.:

Active Members, by death	3
" " " resignation	1
" " " transfer to Honorary	1
Total	5
Associate Members, by death	1
" " " resignation	1
Total	2
Honorary Members, by death	1

Leaving 331 Active, 62 Associate, and 7 Honorary members on the roll, a total of 400, and a net gain during the year of 73 members.

Of the 400 now on the roll fifteen Active and three Associate Members are three years in arrears for dues and should they all be dropped it would reduce the number on the roll at the close of the convention year to 382, and the net gain to 55.

At the last convention eighty-two dollars was received from members recommended by the Executive Committee for suspension.

I have made every reasonable effort to retain these delinquent members, and have heard from a number of them giving as a reason for not keeping up their membership that they were no longer connected with the Water Department; in some cases their successors have made application for membership. Others may be heard from at the convention.

The Associate Members and many Active Members have been active in securing members; one Active Member, whose application was received since the last convention, is credited with one Associate and two Active members secured; such work as this will soon build up the Association to the proportions that it should assume.

FINANCIAL

RECEIPTS.

Cash on hand at close of last convention year	$450.25
Received for initiation fees	485.00
" for annual dues	1,695.00
" for advertisements in the Proceedings	479.00
" from sale of Proceedings	17.00
" from sale of Badges	23.50
" from Michigan Passenger Association, fee refunded	6.00
	$3,155.75

DISBURSEMENTS.

Stenographer, Detroit Convention.	$140.00	
Expenses Detroit Convention	61.90	
Salary of Secretary-Treasurer	800.00	
Office Expenses	177.81	
Postage	85.60	
Postage and Express on Proceedings	151.97	
Printing Proceedings	1,404.90	
Expenses Insurance Committee	25.34	
Members' copies of papers, 1903	79.75	
Programme St. Louis Convention	11.50	
Office furniture	6.25	
Association Badges	4.00	
Advance copies of papers St. Louis Convention	63.55	
Members' copies papers, 1904	29.00	
		$3,041.57
Balance cash on hand		$114.18

On motion, the report of the Secretary was received and filed, and ordered printed in the regular proceedings.

REPORT OF REPRINT OF PROCEEDINGS.

SECRETARY: At the last Convention by a resolution passed on recommendation of the Executive Committee, I was directed to make an estimate of the cost of a reprint of the missing numbers of the Proceedings and of complete bound sets. I accordingly made an inventory of the copies in stock and estimated the number of pages that it would be necessary to have printed to make up editions of from 100 to 500 complete sets, and found it to be as follows, viz.:

Copies on hand.		Pages required to print editions of			
Year.	Number.	100	200	300	500
1881-6.........	0	600	600	600	600
1887..........	520				
1888..........	182		162	162	162
1889..........	453				144
1890.........	325				184
1891..........	639				
1892..........	600				
1893..........	0	212	212	212	212
1894..........	0	217	217	217	217
1895..........	105		146	146	146
1896..........	56	254	254	254	254
1897..........	41	224	224	224	224
1898..........	0	208	208	208	208
1899..........	54	280	280	280	280
1900..........	0	206	206	206	206
1901..........	16	262	262	262	262
1902..........	154		361	361	361
1903..........	308				702
Total pages		2,463	3,132	3,132	4,180

ESTIMATED COST.

Edition of	Total cost bound.	Cost per Set.
100 Sets.............	$3,513.00	$35.13
200 "	5,342.20	26.73
300 "	6,358.40	21.20
500 "	9,834.00	19.67

More sets should be printed than actually subscribed for, to provide for future demands.

100 subscribed for 200 printed, cost per set......	$40.00
200 " " 300 " " " "	30.00
300 " " 500 " " " "	25.00
500 " " 800 " " " "	25.00

The association have no funds for this work, it would, therefore, have to depend upon subscriptions, and cannot be accomplished unless, at least, 100 sets are subscribed for at $40.00 per set. This would, of course, give the association the advantage of having 100 unbound sets to dispose of as demanded. The estimate is made for substantially bound books, several years proceedings in one volume, making up to and including the Proceedings for 1904 seven volumes.

These volumes would make a very valuable water works reference library, and the cost should include a complete index—though this was not taken into account when procuring the approximate estimate.

The Secretary read the report of the Special Committee appointed to audit the accounts of the late secretary and effect a settlement with his estate; which on motion duly made and seconded was approved and the committee discharged:

REPORT OF THE AUDITING COMMITTEE.

To the Members of the American Water Works Association.

Gentlemen: Your committee appointed to audit the accounts of the late Secretary, Mr. Peter Milne, and to effect a settlement with his estate, beg leave to respectfully report that so far as they can learn, no progress has been made towards settling the estate or closing the litigation in which it is involved.

The Association's claims have been properly presented by your Committee and there seems nothing further for your Committee to do, and we, therefore, ask that the matter be referred to the Finance Committee, and the Auditing Committee discharged.

Respectful submitted,
F. W. SHEPPERD, *Chairman.*
ANTHONY P. SMITH.
J. M. DIVEN,
Committee.

At the request of Mr. Keeler, chairman Publication Committee, said committee was given further time to make report.

Mr. Dabney H. Maury, chairman Committee on Electrolysis, submitted the report of that committee, which, on motion of Mr. Caulfield, was received and adopted and ordered printed in the proceedings, viz.:

REPORT OF COMMITTEE ON ELECTROLYSIS

To the American Water Works Association.

Your Special Committee on Electrolysis respectfully begs to submit, as follows, its report:

During the past year there have been, so far as your Committee has been able to learn, no decisions in the Electrolysis suits which were pending at the time of its last report; but there have been new complaints of injury from many sources; and new actions for damages resulting from electrolysis, and for the removal of the electric current from underground pipes, are contemplated in a number of cities.

The underground conduit system of street railways in New York and in Washington. D. C., and the double overhead trolley systems in the District of Columbia, in Cincinnati, in and near Havana, Cuba, and in a number of European cities, continue in successful operation and without injury to water pipes.

Your Committee can, therefore, find nothing to change in the recommendations contained in its previous reports; but, on the contrary, again fully endorse the wisdom and propriety of the action of the American Water Works Association in adopting, after careful consideration and without a dissenting vote, the preamble and resolutions embodied in the report of the Committee of 1901, as an expression of the attitude of this Association on the question of electrolysis.

Respectfully submitted,
Dabney H. Maury,
G. H. Benzenberg,
J. Waldo Smith,
Special Committee on Electrolysis.

Mr. Nourse: Is it understood that the Committee on Electrolysis is a standing one?

Secretary Diven: Yes, sir. I had a telegram last evening from Mr. J. J. R. Croes, chairman Committee on Standard Specifications for Cast Iron Water Pipe, advising that his report was on the way and will be presented by Mr. Benzenberg, a member of that committee, who will be here Thursday. I ask that the hearing of the report be deferred until that time.

On motion, the committee was granted time accordingly.

The Chair called for the report of the Committee on Uniform Classification of Accounts.

Mr. Gwinn: As chairman of that committee, I will state that we have done some work in the way of collecting various data with respect to forms and methods of conducting water-works business. It is a work of some magnitude that I think will take four or five years to complete in proper shape. I would rather somebody else would do it, but I have presented a paper on the subject, in a general way, which I have handed to the Secretary, and as he has not the same at hand at this time, I would ask that the report may be submitted later.

On motion, the request was granted.

On motion of Mr. Keeler, the Committee on Standard for Water Rates was given until Thursday to make report.

Secretary Diven reported the following resignations, which, on motion of Mr. Simpson, were duly accepted, viz.:

RESIGNATIONS.

ACTIVE MEMBERS.

E. H. Welles, with Babcock & Wilcox Co.

ASSOCIATE MEMBERS.

Lamb & Ritchie, Cambridgeport, Mass.

Secretary Diven read the names of members deceased during the past year, viz.:

HONORARY.

Frank W. Holly, M. E., Lockport, N. Y.

ACTIVE.

Charles Fred Allen, Treasurer Water Company, Hyde Park, Mass.

Lester E. Wood, Director Green Island Water Supply Co., New York, N. Y.

A. W. Scoble, Superintendent Water Works, Ft. Worth, Texas.

On motion, the Secretary was directed to prepare a Memorial Page in the minutes of proceedings of this meeting in memory of the deceased members above named.

Mr. C. H. Campbell, chairman Committee on Insurance, submitted the report of that committee, viz.:

REPORT OF COMMITTEE ON INSURANCE

To the American Water Works Association.

Gentlemen: Your Committee appointed to consider the subject of fire insurance and private fire protection, beg leave to report as follows:

The Committee met in New York City on November the 28th, and as it was deemed important to enlist the interest of the manufacturers of meters and other devices for measuring water, several representatives of the meter manufacturing companies were present. Description of the various appliances for measuring water on fire lines was submitted, together with data relating to the pressure lost by such devices, and their efficiency in meeting the requirements for measuring small and large streams without undue restriction of pressure, was thoroughly discussed by the Committee. We are satisfied that considerable progress has been made towards the accomplishment of the desired results, but consider that the tests have not progressed far enough to warrant your Committee in recommending any particular device at this meeting. Since it was considered important to collect data bearing on the various subjects relating to the duties of the Committee, the following sub-committees were appointed:

A Committee on Fire Insurance Rates and the saving to the insured, which is effected by the installation of private fire protection, whether by simple hydrant on premises, stand-pipes in buildings, or complete sprinkler head protection, Mr. J. H. Purdy of Pittsburg, Pa., being Chairman.

Committee on Scientific Basis for Rates to be charged by Water Works Departments or Companies for the different classes of private fire protection. Mr. M. R. Sherrerd of Newark, N. J., Chairman.

Committee on appliances for measuring water supply for private fire protection, so as to prevent waste and still maintain pressure. R. J. Thomas, Lowell, Mass., Chairman.

Committee on Fire Insurance Laws and Rates and Insurance Maps. F. W. Shepperd, Chairman, New York.

The Committee also requested the manufacturers of meters and measuring devices to exhibit at the St. Louis meeting any appliances they may have which will meet the purposes of this Committee.

At a subsequent meeting of this Committee, held in New York on May 25th, the various sub-Committees reported, showing satisfactory progress, but each was impressed with the magnitude of the question, and requested further time in which to digest and report upon the data which had been gathered.

At this meeting, besides several representatives of the meter companies, we had the pleasure of listening to Mr. Alfred M. Quick of Baltimore, Md., while he described the terrible conflagration that had so recently devastated the City of Baltimore, and the trials and successes of the Water Works Department during that ordeal.

The Committee, having received both collectively and as individuals, an invitation from the National Fire Protection Association to attend the sessions of that body, then being held in New York, it was decided to attend on that date in a body. Mr. Nichols S. Hill, Jr., Chief Engineer of the Water Department of New York City, and Mr. Alfred M. Quick. Water Commissioner of Baltimore; Md., joining the Committee on that occasion.

The following resolution and request was passed by the Committee and presented by the Chairman, Mr. C. H. Campbell, to the meeting of the National Fire Protection Association. and we were assured that the request therein made for the appointment of a Committee to act in concert with your Committee, would be favorably considered. The resolution is as follows:

New York, May 25, 1904.

National Fire Protection Association,
32 Nassau Street,
New York City.

Gentlemen: In response to your kind invitation to attend the sessions of the National Fire Protection Association being held in New York at this time, our Committee on Fire Insurance and Private Fire Protection have been in session and have had reports from different members on their experiences in supplying private fire protection and services under the present practice and requirements of the insurance companies. They have collected statistics from many cities and water companies. The question is such a large one. and the development of private fire protection has developed so rapidly, that we feel like asking your Association to withhold the fixing of arbitrary requirements at this session, feeling that such arbitrary requirements, if insisted upon, may run counter to the conditions, limitations and obligations under which many of the Water Departments have been constructed, and we would respectfully request that your Association appoint a standing committee with whom this Committee, or its successors, representing the American Water Works Association, may confer from time to time during the coming year, with the hope that we may develop specifications and conditions that may be mutually beneficial and satisfactory. Some of the demands of raters which have been in cases reported to us have been of such a character that from the standpoint of the best hydraulic engineers are unreasonable and unnecessary and cannot be complied with by Water Departments or Water Companies, and if insisted upon would entail such cost as would make it prohibitory.

Respectfully submitted,
Committee on Fire Insurance and Private Fire Protection.
By C. H. Campbell, *Chairman.*

The above resolution, having been handed to the National Fire Protection Association, Mr. Purdy explained the scope and limitation of the resolution and the desire of the Committee to co-operate with the insurance people toward attaining standard requirements for the installation of private fire protection along lines which would be mutually advantageous to the assured, the Insurance Companies and the Water Works of the various cities throughout the country.

During the discussions in your Committee, the following recommendations were adopted, to be presented at this time:

First: That since the protection afforded by private fire lines is a valuable consideration, and since they, in a measure, effect the efficiency of the Water Works in fulfilling its duties to the general public, in case of a general conflagration, the services so rendered should be paid for by the owners of the property so protected, and that the appliances for introducing and measuring the water should be paid for by said owner, just as much as the piping, hydrants and sprinkler heads inside the building or on the property.

Secondly: That since the tendency throughout the country, and the decision of some courts, seems to be to throw responsibility for losses by fire upon the Water Works of the various municipalities, we deem it very important that no contract for supplying water for private fire protection should be entered upon without a clause adequately protecting the Water Works Company or Department from damages, if any exist, that may arise from the deflection of the water supply from the private property for the public welfare.

The public weal is of greater moment than that of any private individual, and its demands and the duties of the Water Departments to comply with them should never be placed in jeopardy for the sake of private interest.

Third: That the question submitted to your Committee has such wide scope, and is of such great importance, that we feel we have only made a beginning upon the work before us. It is therefore respectfully suggested that this work should be entrusted for another year to this Committee, or a successor.

The success attending our endeavors in the courteous co-operation of the National Fire Protection Association leads us to hope that much good and lasting benefit can be accomplished during the coming year.

The large amount of work and time consumed in collecting data and attending the meeting of the National Fire Protection Association, has made it impossible for this Committee to confer as it would wish with the Committee of the New England Water Works Association, and the Central States Water Works Association, but we hope to take up this and kindred subjects with them during the coming year.

Respectfully submitted,
C. H. CAMPBELL, *Chairman.*
A. E. BOARDMAN,
GEO. H. FELIX,
R. J. THOMAS,
J. H. PURDY,
M. R. SHERRERD,
F. W. SHEPPERD.

Mr. Campbell: I may add that since that report was made out I received a wire from Mr. W. H. Merrill, Jr., who is secretary of the National Fire Protection Association, in which he says that a conference committee will be appointed.

On motion of Mr. Tucker, the report of the Committee on Insurance was received, and the committee continued.

Vice-president Sherrerd requested Mr. Campbell to add a further description of the work of the committee in connection with the New York meetings.

Mr. Campbell: Gentlemen of the convention, in response to the request of the president for me to give you some description of the work of the committee in New York City, the report submitted, I might say, fully covers the principal features of it, and I do not know that I can say anything to better elucidate the subject than is therein stated, except to add this: I hope that you will not consider me immodest in stating this, because, if the committee consisted only of my own personality, I would not do so; but there are six on that committee besides myself, and I think I can say to their credit that they feel that the work they have in hand is one of very great importance—of such great importance that we will not allow ourselves to go too deep into the subject at one time, because we have thought it best to first work out and establish ourselves on some one proposition and carry it to a successful conclusion. We believe that one thing in which we have made material progress is the appointment of this conference committee with the National Fire Protection Association. You all know what that association is, that it represents the Underwriters of America. Every one of their men who attend their annual meetings is, as I understand it, a paid and salaried man who goes there for that express work; on the other hand, the members of our committee have gone to New York City at their own personal expense, yet we believe that we will be fully compensated for any expense thus incurrd, and we also feel that the work we have inaugurated will pretty nearly take up the entire time, perhaps, of our Secretary here, or some other active person, in solving this question in concert with the National Fire Protection Association. We believe that it is possible for perfectly well intentioned men to disagree on points of detail, simply due to lack of information or proper knowledge of the subject. Sometimes differences of opinion arise because of lack of knowledge upon one side or the other of the existing local conditions. No man knows the local conditions as well as the engineer in charge. I believe that the water-works people in this country are not seeking to evade responsibilities resting upon them. They are patriotic men looking after the interests of the fire protection service in their respective communities; and we want to get our men together so that if any one man in any certain section of the country has any trouble with regard to questions of insurance, that he can find support or help in the preponderance of our opinion on such subjects sufficient to create a public opinion favorable to us as it has been in the past favorable to insurance interests.

We do not want to make any fight against insurance people, because we recognize in them good clever gentlemen who are looking after *their* interests, and we want to do exactly what they are doing, that is, to get together on some proposition. In this there may still be opportunity left for differences of opinion that must be settled by the local men themselves. (Applause.)

Chairman Sherrerd: I believe that this question of the adjustment of differences between water-works managers and the insurance people is one of the most important subjects that will come before this session of the American Water-Works Association. When the committee first took up this matter I think that none of us appreciated the scope of the work that could properly be undertaken by it. There enters into this question the consideration of many new conditions in modern construction, to which I referred last night, including the supply of water for high buildings, especially fire protection, high pressure fire lines, and matters of that kind. These have been gone into to some extent by this committee, and, as Mr. Campbell has so well said, attempting to cover these different phases the work has not been fully completed, and that is why it is thought that this committee should be continued.

I understand that there are representatives present of the National Fire Protection Association, and I suggest that the privilege of the floor be extended them.

On motion of Mr. Maury, the privilege of the floor of the convention was tendered to Messrs. Robinson and Blauvelt and the representatives referred to.

Mr. W. C. Robinson (representing National Fire Protection Association):

Mr. Chairman and Gentlemen:

I have but a few words to say. We were very glad to receive your committee in New York, and as representing the National Fire Protection Association I can say that a committee probably equal in number to your committee will be appointed to meet with your committee and discuss the question which your chairman, Mr. Campbell, has brought before you. I have no doubt that all the differences of opinion, particularly those of an engineering character, can be worked out on some common basis. I know we are both after the same thing; that is, a thorough fire protection. If that fire protection, as demanded at present, is going to be more detrimental in other respects than it seems to be in the places where we are asking for it, then in those localities we desire to get together with you and find out what are the points of difference and to overcome them, if possible. If we are asking for any service that is going to injure the balance of a city, why, it would seem that that would be unwise.

I think that in all probability during the coming year, although I have not had a chance to talk with any of your representatives, that this matter can be very considerably advanced, and an agreement, at least, in sight. I thank you, gentlemen. (Applause.)

Mr. Albert Blauvelt, Associate Manager Western Factory Insurance Association, Chicago:

Gentlemen:

I can only reiterate what Mr. Robinson has said. We feel that the course adopted by your committee is a wise one. The general subject under consideration has several branches, and cannot be hastily settled. I can say with confidence that we are not going to find many insurance men who will deny that your service is a valuable service. We all know that it is, and that you should receive compensation for it. I do not believe that insurance men have any right to make any expression as to how your compensation should be secured. That would seem to me a matter between you and your customers, and controlled by your charters, your local legislation, and things of that sort. So far as my own experience goes, and my department is concerned, I come in contact with quite a good many water works men throughout the Central West, and manage to get along without any very radical difficulties with a majority of those gentlemen. I do not see why fairly amicable relations should not continue. I think my confreres will say the same in other sections of the country. The general course that has been adopted by your Association is precisely the one that will bring good results in the end, and if you will continue your work you will reach such, I hope, in a year's time. The one that will bring good results in the end, and that if you will continue your work you will reach this, I hope, in a year's time. (Applause.)

Secretary Diven: I would like to ask you, Mr. Blauvelt, while you are here, if Mr. Gwinn has got his blue print yet?

Mr. Blauvelt: Yes, sir, I sent Mr. Gwinn the blue prints. (Laughter.)

Mr. Gwinn: I was only waiting for Mr. Blauvelt to set down so that I might acknowledge the receipt of those blue prints.

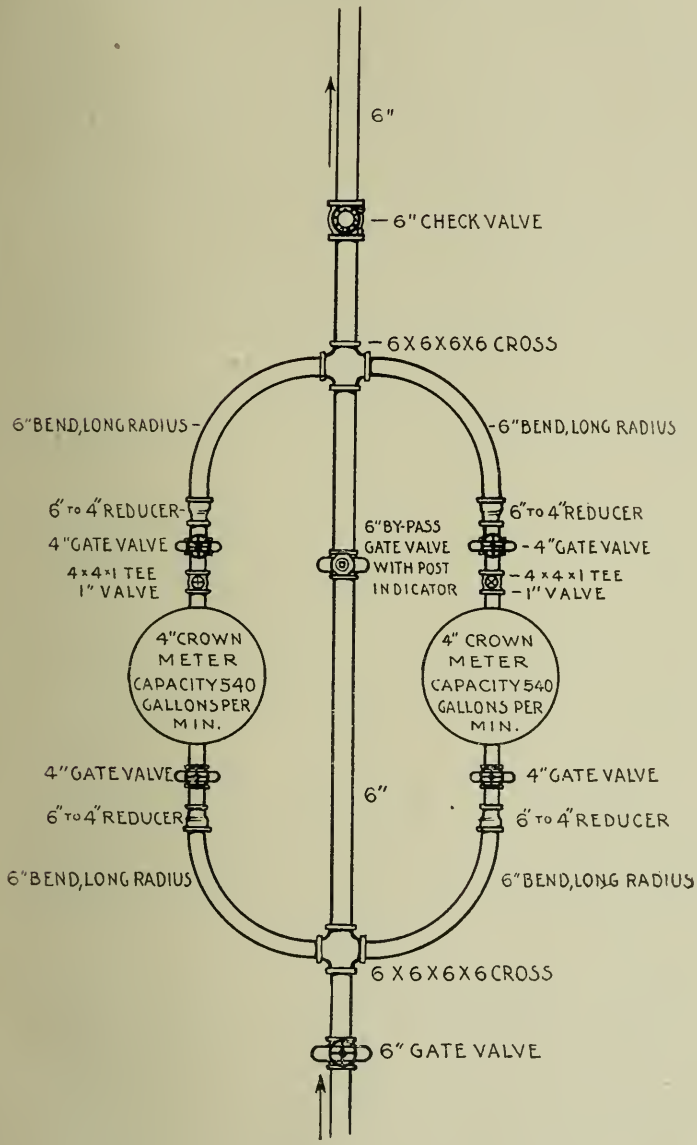
The only objection to the blue prints furnished by Mr. Blauvelt is, that they are copies of the original lay-out of the surveyor who is sent out to look over the land. When it comes to doing the work, the foreman does the best he can in the way of following the lay-out, but frequently finds obstructions underneath the surface of the ground, such as sewers, abandoned cisterns, etc., that interfere with the original plan. The result is that when the work is completed there is considerable variance between the actual conditions and lay-out.

If we could get a plan of the work, as completed, drawn to a scale, showing the buildings and the location of underground pipes, it would be of considerable value to us.

Since we had our discussion last year, we had an application for a 6 inch fire protection line with four fire hydrants for a manufacturing concern that had made provisions for pumping its domestic or general supply of water from driven wells. After considerable discussion, we agreed that the fire protection line should be controlled by meters.

A number of members of this Association object to metering fire protection on the ground that the large meters will not register small streams. Now, I do not object so much to the loss of small streams as I do to the large streams. Most of the devices which have been invented for controlling fire services have been along the line of registering the small streams and allowing the large streams to pass through without registration. This plan would be satisfactory if all large streams were used for fire purposes only. As a matter of fact a manufacturer soon learns that large streams can be drawn through without registration, and if he has no conscience, is very apt to get a large portion of his water supply from the Water Company or Department without paying for it.

I believe the best meter for a fire service is the Positive Displacement meter, and I am satisfied that they will register very small streams with reasonable accuracy. However, as stated before, I do not object so much to having the small streams pass without registration as I do to losing a large quantity of water, as would be the case where detector checks are used.



CONTROLLING WATER FOR PRIVATE FIRE SERVICE.

You will see by this sketch (I will have a copy made for the proceedings) that we used two 4″ Crown meters and put in a 6″ pipe. We used regular 6″ bends which were reduced at the 4″ valve, the object being to have the area large enough to allow for friction. We placed a 4″ valve on the inlet of each meter; on the outlet we put in a 4″x4″x¾″ tee and then a 4″ valve. The object of the tee is to provide for the testing of the meters; this can be done very easily by connecting a smaller meter with a ¾″ hose. By having valves on each side of the meters, either meter can be removed for repairs without cutting off the supply. Each of the 4″ meters will deliver 540 gallons per minute, making a total supply of 1,080 gallons per minute. I believe that you will agree that this is a satisfactory supply for fire protection.

You will see by the sketch that we have a 6″ by-pass controlled by a valve. This valve is sealed so that if the valve is opened we will know it. Our men make examinations of meters and seals every month. I will say in this connection that the ordinary wire can be pulled out of a seal and put back again. To overcome this, we use a double copper wire; that is, one wire wound around another. It is impossible to pull these wires from the lead seal and restore them.

In case of a severe fire the manufacturer has the privilege of breaking the seal and opening the 6″ valve, thus giving a full 6″ supply. However, the two 4″ Crown metres, or even one of them, will be sufficient for an ordinary fire. Our plan also provides for a check valve on the outlet.

We prefer to set the meters in a large brick well on the sidewalk or just outside of the private property. With this plan the manufacturer can put in as many fire hydrants as he pleases and can also have any number of stand pipes with hose valves for inside fire protection, also connections with boilers, office, stable, etc. All cost of pipe, valves, meters, hydrants, etc., is paid for by the consumer. We charge a minimum rate of say $25 a month and allow the consumer to use 5,000 gallons of water per day, or 150,000 gallons per month. The consumer is charged for water used in excess of 150,000 gallons per month at schedule rates or such rates as may be agreed upon, depending upon the amount consumed. We request the consumer to use the amount of water allowed in order to keep the meters in good working order. By using that volume of water there is not much danger of the pistons being stuck.

The concern referred to put in four fire hydrants, 13 standpipe connections. My recommendation was that they put in a great many hose valves so that with a 50′ line of hose on each one, they would be able to reach any section of the building. I believe this plan is a good one, as most fires can be put out in their incipiency, and it is based on the idea that a small amount of water available at the beginning of a fire is of greater value than a large quantity after a fire has gotten beyond control.

In our contract we specify that if a large quantity of water is used through a meter to extinguish a fire, we will come to some agreement with the consumer as to what the charge should be. Our idea is not to make any charge for water used for fire purposes.

I believe this is a fair solution of a difficult problem and the Water Company is protected from loss of water either in small streams or large streams; it receives a certain sum for the service if only a given amount of water is used, and a larger amount if the consumer desires a general supply. The manufacturer can have as many fire hydrants, stand pipes, etc., as he chooses to pay for and has the use of 5,000 gallons of water per day for the minimum rate of $25. The manufacturer is relieved of annoying inspections, and is at liberty to use what water he wants at any time. This plan has been in use for some months and has proven very satisfactory indeed, and I take pleasure in recommending it to Water Companies and Departments that are looking for a solution of a vexatious problem for supplying fire protection to private property.

Mr. Blauvelt: In connection with the remarks made by Mr. Gwinn, I think that the exposition he has made of the question is a very clear one, and directly to the main point which will require most discussion in the work of the respective committees that have been appointed. Speaking for the department I am connected with in Chicago, such an arrangement as Mr. Gwinn has indicated would be satisfactory, with one exception, and that is that the gate he speaks of, which the property owner has the privilege of opening in case of a very severe fire. We must provide better than that for the contingencies of a very severe fire. I would like to have you understand why it is that we are so sensitive about what may seem to be a very far fetched contingency. The protected properties are taken at a very low rate—one-half of one per cent. and less, and if you insure for one-third of one per cent. annually, and take off expenses—pay me for standing here and talking about it—you will not have a great deal of money to pay fire insurance losses out of that one-third of one per cent. per annum.

We are serving corporations having perpetual life. We are not thinking of anything that is to happen while you men are alive. We do a business that runs into very small contingencies and is delicately balanced, when you take expenses off. We do a current business and do not draw interest on the premiums taken in. A corporation having perpetual life cannot afford losses accumulating to equal a total loss within several hundred years at rates under one-half of one per cent. That is the reason we lay such great stress on what appears to you gentlemen as a very remote contingency.

We have found, taking properties scattered all over the country, that if you are going to have an automatic service you must have it automatic in all respects.

Without making any attempts to foreshadow the action of the committee who will work during the year, if the gate that Mr. Gwinn speaks of is closed, even if capable of being opened by hand, I know that insurance people rightly feel that the exigencies of their business are such that that gate should be something which in an emergency will open itself and have no chance of sticking or of depending on manual aid.

MR. GWINN: We have a supply there of 1,080 gallons of water per minute. Would not that be sufficient?

MR. BLAUVELT: That is precisely what we are unwilling to bank on. I do not wish to take up the time of you gentlemen by repeating my Detroit address, already published in your proceedings. I did not attend your meeting at Detroit as a representative of the National Fire Protective Association. I had the pleasure of being the guest of your Association by invitation of your secretary. What prompted your secretary to write me before I do not know, but the invitation was sent and responded to. Of course, I am very glad to be the recipient of any courtesy or to reciprocate any courtesy possible to your Association. In addressing you at Detroit last year I endeavored to point out that we cannot trust any meter, no matter how perfect. We believe that the stones, hemp, lead, leaves and other obstructions that draw during the rush of fire service into the working parts of meters are too fatal to any type of meter to make them as reliable as we feel a fire protection device must be where we are carrying enormous values at such very small rates. We have to secure ourselves against practically every known or possible contingency. Otherwise we cannot do the business on the basis on which we do it.

As stated at Detroit, it is not necessary in the art of fire protection to have anything to do with water works. We can protect property out in the middle of a square mile vacant lot. The matter of connecting with water works is simply a commercial question whether to do so or put in a private supply. Where people put the question to me, I tell them to pay the water works, if necessary, on a basis from twelve to fifteen per cent. of the cost of whatever else they would have to put in to do without the water works connection. But I cannot make too emphatic the fact that modern fire protection has reached such a high degree of refinement that competition has forced the rates down very low, which point has only been reached by implicit dependence on absolutely automatic water supplies. We will not take one supply—we have to have two. Directly you put in the supply line, any device that is capable of getting into trouble, then we begin to wonder if that is not worth more rate.

Mr. Maury: The discussion thus far suggests to my mind three points: First. as soon as Mr. Gwinn showed his drawing, I thought that I saw in it one objectionable feature which would not meet the approval of the fire insurance people. That was the presence of the gate, which, in order to give full efficiency to that service had to be opened by hand after the fire alarm started. I can readily see the justice of the position taken by the representative of the fire insurance side of the qustion, and if I were in his place I, myself, would not wish to have that gate on service. One other small point: I think I have spoken of it here before, and with respect to it I should like to convert the engineering staff of the fire insurance people. They seem to think that protection is best secured by putting on a limited number of hydrants with a large number of independent nozzle gates. Now, if there is any invention, any one design that confuses men at a time when everything ought to go smoothly and easily and without failure, it is a hydrant with gates on the nozzle.

The rational solution of that problem is to put on a large number of hydrants and no nozzle gates. No fireman can ever be counted on to know or remember whether the nozzle gate is open or shut. I think I have before stated an instance where we had one six nozzle hydrant with six nozzle gates, and one three nozzle hydrant with these nozzle gates. The fireman succeeded in getting one stream off the three nozzle hydrant and broke the stem of the other two, and one stream out of the six nozzle hydrant and broke the stems of the other five, thus securing two streams out of a possible nine.

The third point that suggests itself to me in connection with Mr. Blauvelt's remarks is this: I think that any joint action or recommendation that might be taken or proposed by these two committees should not extend to the question of rate. That matter should be left to settlement by those who have to deal with it as business men between business men; and no set of men sitting here should legislate for them. (Applause.)

Br. Kimball: The longer the question is discussed, the less we know about it. I will not say that, however, unqualifiedly, for I think we know considerable more about it than we did a few years ago—but the further we appear to be from a settlement of the question. Mr. Blauvelt made a very pertinent suggestion to this Association, I think, in speaking of the premium for insurance that they were paid, as including therein his expenses and time standing here and talking to you.

This Association itself cannot go to the expense of investigating this question and of paying gentlemen for travelling around the country investigating the best appliances. Let the insurance people do it. That is a part of their regular expenses and a part of all the premiums that are paid for insurance go to liquidate just such expenses. I think we are on the right track to settle this whole question. I do not think it can be settled in the convention hall, but it can be settled, if at all, by a conference between the parties most interested. You might say that the manufacturers, being the ones who are protected, are the ones who have the greatest interest in it; and yet, without attempting to mince matters, they have practically no choice, they having to pay what either the insurance people or the water departments say, or let it alone. Of course it is to the interests of the insurance people to have unmetered fire services. It is much more, I think, to the interests of water departments to have manufacturers and others having properties the subject of fire risks, satisfied, and at a price which will not be prohibitive. The insurance people say that if you put a meter on the premises they will raise their rate. They do not exactly say they will prohibit it, but they will raise their rate. The water works departments in many instances say they will not supply fire protection except through meters, or some other controlling devices, simply because they are the only things that have yet proved to be proper inspectors of private fire systems. In other words, except in a system of pipes which come directly into the building, where all the pipes, valves and other appurtenances are above ground, it is impossible to keep up with the inspection of it in any other way than by metering it absolutely. I doubt if there is a water works man present who will gainsay that statement.

As I said before, this matter cannot be settled on the floor of the convention hall, but must be settled by conferences and by experiments, probably through a long series of intricate processes. I think it quite likely, as a previous speaker has stated, that it may take perhaps five years or more before we can get at it, although possibly it may be done sooner.

It seems to me that it is too much to ask the gentlemen composing this Insurance Committee to devote not only their own time, but to pay out of their own pockets the expense of travelling to common meeting points, and of hotel bills, together with what seems to me to be of still more importance, the expense of tests and of apparatus, necessary to determine this question. It is probably out of the question for this Association to meet this expense as fully as, in my opinion, is necessary. The insurance people, I venture to say, would not hesitate to spend thousands of dollars to protect their interests in this direction, and if the expense should exceed their expectations, why, all that is necessary is that they advance their rates say one-fifth of one per cent., and thus meet the deficit. We cannot do that, but I think it would be possible for this insurance committee, or perhaps our secretary, to ask the water companies and water departments to contribute, say, five dollars or ten dollars apiece towards a fund for the carrying on of these tests, conferences, etc., or, to put it another way, for the benefit of the committee to use in the settlement of this qustion, which will at least put them on a nearer equal footing with the insurance people in the matter of meeting expenses necessarily incurred in their work.

I think the solution of the question is to be reached by getting together, and to do this properly the committee representing the water works side of it must be placed in an equivalent position to that of the insurance people.

I would therefore move, Mr. President, that the Insurance Committee, in conjunction with the Secretary, issue a circular setting forth their work and what they desire to accomplish, copies of the same to be mailed to each or all of the water departments or water companies as they deem proper, perhaps those in towns of say ten, fifteen or twenty thousand population and upwards, asking them for a contribution of five or ten dollars apiece. In this way a fund might be raised that would place our committee on an equal footing with the insurance interests. I believe our committee is fully able to handle the question.

but if they do not feel capable of giving both their time and contributing their expenses to it, they would then be in a position where they could hire or obtain expert opinions and experience to settle any question which might arise. I do not believe these matters will be settled until the two interests, the insurance people and water departments, do agree upon some common method of handling and protecting these risks. I therefore make that motion, Mr. Chairman, that such circular be prepared and sent out, soliciting contributions to meet such expenses as the committee, in conjunction with the secretary, may deem advisable.

The motion was seconded.

CHAIRMAN SHERRERD: I think the matter might, perhaps, well be left to the discretion of the committee. The committee has opportunities for testing these appliances without expense to the Association. Mr. Campbell, I would like to hear from you before the question is put. I suggest that it be left to the discretion of the committee rather than made obligatory upon them.

MR. CAMPBELL: I do not know—I think it would be a good idea to get the sense of this meeting with regard to the resolution, not as a demand but leaving it optional with the committee.

CHAIRMAN SHERRERD: Perhaps I misunderstood the motion. I thought it was a direction that the committee do this, not simply an authorization.

MR. CAMPBELL: Mr. Kimball's idea was to help the committee.

MR. NOURSE: My experience in matters of this kind has been that in sending out a circular you would not get back as much money as the circular cost you; and if this Association is not able to meet the gist of the question that is before it, let it discharge the committee, and let it alone. When this proposition was first suggested—if the suggestion which came to my attention was the first one, at Chicago, it met my hearty co-operation, for the reason that I believe that the bringing of the fire people and our people together would accomplish much in the interest of water-works systems, as well as protection to the general public; and for that reason I entered into it with Brother Campbell and the others.

Personally, I wish that the conduct of the bureau I represent might be on such strict business principles as to figure down to one-fifth of one per cent., as our friend has stated the insurance people do, which would tend to bring into the water-works systems of this country the application of that kind of business methods that would enable us to accomplish something. It is with shamefacedness that I stand before this Association to-day and admit that seventy-five per cent. of the water that is pumped in the city of Chicago goes to absolute waste, and in other water-works systems throughout the country the same condition exists, if not to a greater, to a lesser extent. If a like condition existed with regard to the management of insurance companies they would have to go out of business. The only reason why we cannot get our work done on the same basis of business principles and careful calculations is because we have to depend on too many political influences to bring about a change in conditions.

In regard to the diagram which our friend showed, this is the way we settle that matter in Chicago—and we settle it very quickly. We made our ordinance so that under no circumstances should there be a by-pass or run-around. We made our ordinance read that if an establishment desired to have an independent fire protection it might have it, provided it would place a meter which would not interfere with the flow of the water, subject to the approval of the Department of Public Works, and reserving the right for it to have the approval of the insurance people as well.

We put on a fire line a non-positive meter, and in each case where such meters have been applied they have had the approval of Mr. Southard, the Underwriter's agent in Chicago. We never have any trouble. We give the insurance people to understand that there will be no charge whatever except the charge incident to the supplying and placing of that character of *detective* that we ask to be placed there, and in case of fire we give them just as much water as they want for the protection of their property, and incidentally the protection of the common property all around.

If you will take the pains to study the charters under which water-works companies are organized in this country, I do not believe that you will find one single solitary charter that is based upon any conditions made that any other interest should be protected. The charters of the Municipal companies are based upon the idea of the doing of all the good that we can for all the people interested, at as slight a cost as possible. The charters of private companies are based upon an economical business administration of a water-works system with established rates that will pay expenses and remunerate the parties that are giving the benefits. Our charters do not include any thought that we are claiming to do anything for a fire insurance company, and, as our friends say that they care very little in establishing their rates, whether they take into consideration the juxtaposition of fire appliances to the risk they are taking, because they can make their own protection, and fix their rates to suit. But, in the management of a great industry like the water bureau in a large city, it is necessary that we take into consideration, as I stated on this floor before this convention a year ago, one of the most important elements in human life—plenty of pure, good water, second only in the protection of life and health to good, to pure air that we take into our lungs; and it is due from every one of us that every precaution that can possibly be taken be adopted for the protection of the people whom we represent.

With reference to the charge of $25 a month for a specific thing, we do that in this way: We say, "You cannot have water for this purpose unless you pay for all you use. If you are a manufacturer and want fire protection, you must put a meter on your line that will meet our approval and the approval of the insurance people as well; and we have no trouble whatever, it gives you all the water you want to put your fire out, but we charge you for all you use should you wish to open the valve at any time. Those fire lines are automatic. Come up and look at them. All you have to do is to open them, they are absolutely automatic. I had a circular from the manager of an insurance company in New York—I do not recall his name—and he, not knowing the organization in Chicago, I wrote back to him and asked him to subdivide his circular of inquiry up, and to send certain parts of it to the fire department, other portions of it to the civil service commission, to the police department, and to the department of public works. In that circular their inspector stated that there was a necessity of increasing the pumping capacity in Chicago, but in this he was in error. It is not the increase of pumping capacity that is needed, but the stoppage of waste. I wrote to him, saying we did not need any more pumps in Chicago, but we did need to preserve the water that was pumped. If your inspector were at a fire and a fire engine was directing water on the conflagration, and the hose were to burst, and the firemen would connect another engine on to that hose, to force more water through, would that not be condemned by your inspector? Now, I have digressed from the question, but I have done it for a purpose, and I hope that the committee from the fire protection people and our committee jointly will look into this question of the enormous waste of water and that every water-works man will investigate it and, if possible, suggest a remedy.

Incidentally, I may say that if you have any objections to our system in Chicago, come up and let us show it to you.

MR. BLAUVELT: Mr. Nourse has looked at me in such a direct way that I feel constrained to speak, lest a misunderstanding arise.

As I understand it, the subject matter under discussion is one with which the entire city of Chicago is not related. The same may be said of all other cities that do not carry fairly high pressures, and also do not furnish direct fire pressure. We are discussing the subject of meters, or no meters in direct service lines to fire protection systems. In Chicago there are no such service lines. There is no reason, in Chicago, why meters should not be freely used, because the metered water is passed to tank or pump supply reservoirs, and not used as a direct supply.

SECRETARY DIVEN: Water Departments and Companies are going to be directly benefited by the work of this committee. I think, therefore, that it is eminently proper that those who are to be directly benefited should contribute to the expense of the committee. Whereas, if the funds of the Association are used, many who will not be at all benefited will be compelled to contribute; I refer to our associate members and the active members who are not directly connected with water works management, engineers, etc.

CHAIRMAN SHERRERD: The question now before the house is whether this Association shall authorize the Insurance Committee to send out a circular to the different water works throughout the country asking them to contribute a certain sum to be used in the investigation of this subject of water supply for fire protection.

MR. MICHIE: Is the sum necessary for the committee to decide?

CHAIRMAN SHERRERD: To authorize the committee to ask for such a sum as it sees fit.

A vote being taken by show of hands, resulted in a tie.

CHAIRMAN SHERRERD: The Secretary informs me that the vote is a tie. If I have the deciding vote, I cast it in the negative. It seems to me that we are taking too hasty a position in this matter, and that we ought not to go around begging. This Association has gotten to a point where it ought not to beg for funds necessary for a scientific investigation.

MR. O'SHAUGHNESSY: From my personal experience with the insurance people—I may be wrong, but it seems to me that when they insure property they lay down an arbitrary proposition. Their rules and regulations, at least in some instances, in my judgment, could undergo a change that would be advantageous both to themselves and the water works people. For instance. Our manufacturers come to us and tell us that they must have a fire line, that they are compelled to have it in order to secure insurance, but they will not be allowed to have a meter on it. About eighteen months ago we made up our minds that we were going to meter everything in the city, and this was the first difficulty we met with that we could not overcome. The insurance people told the men who were forced to have a fire line that they could not use the water through a meter. Who but the water works people would get the worst end of such a proposition as that? There was ample fire protection intended but no water protection.

If water companies are going to furnish fire protection in such cases, they should be paid for it, and some way should be provided by which their water could not be stolen. If the insurance agents would explain to their customers the objections that the water works would have in regard to making a direct connection without meter, at the same time making it clear that while there was an increased water rate for such a connection, the fire protection was so perfected that it would be offset by a decreased insurance rate, they would make this a much less difficult problem to deal with.

What is going to prevent the use of the water from these fire lines for other purposes than fire? We have merely to trust to the honesty of those using them. At Detroit insurance companies promised us a machine to overcome this a year ago; they were going to have it in operation within a few days. They meet us in St. Louis and tell us that it is not yet perfected, but it will be—sometime, perhaps, but not in our time.

SECRETARY DIVEN: I suggest that anybody having any special devices or plans for controlling fire services send them to our Committee in order that they may be used in the conference with the National Fire Protection Association Committee. The committee from this Association already have one or two designs. I saw in the public press something new had been invented that would be exhibited here, but have been unable to hear anything of it. I submitted one device to the committee myself which I think will overcome the objection of Mr. Blauvelt to Mr. Gwinn's device, with respect to the gate opening automatically. I think this device ought to prove of advantage both to insurance people and fire departments. I believe that above all things these services should have some device for giving notice of serious leaks or other draft on them. I had an experience that emphasizes this: At about ten o'clock at night received word from the high service pumping station that they had lost their pressure; this seemed strange, for in addition to the pumps, this service was supplied from a reservoir holding some three million gallons. I directed them to put on the emergency electric pump—capacity 1,200,000 gallons per 24 hours, and report later. The district is supplied by an eight inch main from the pumps, and in case of excessive draft, by one of the same size from the reservoir—which is filled by the pumps. They shortly reported that the extra pump only raised the pressure by fifteen pounds; I then started out with a searching party to locate the trouble; meanwhile complaints began to come in thick and fast from factories depending upon this supply. The trouble was not found till nearly eight o'clock the next morning; when it was found that a hydrant on a private fire service had blown off. The hydrant had a six inch connection and was located on the bank of a stream running through swampy ground. The pressure at this point was about one hundred and forty pounds, so you can imagine the waste of water. And, worst of all, the other factories—all well insured—were without fire protection during this time, as were also all other buildings in the district. It seems to me that our interests were mutual in this case: while we were having our trouble the insurance people were carrying a great risk, and that they should be ready to join with us in demanding some safeguard against such accidents.

Mr. Charles: The private fire hydrants in our city have no by-passes on them, and they are accessible to all. Anybody can get at them. If an additional supply is desired for automatic sprinklers, we give them to the limit of a 2″ supply pipe with a meter on it. If that does not give them enough water, they must put a tank up to accumulate in. That seems to me to solve the question, it does with us.

Mr. Campbell: While there is at present, I understand, no particular subject before the convention, I would like to say this as to the disposition made of the subject of the sending out of a circular letter by our Committee, in pursuance to Mr. Kimball's generous proposition that these contributions be made, that I felt that before taking any position ourselves as a Committee I would like to know the sense of this Association, and since that decision has now been given against the proposition I want to say that I heartily endorse this decision, Mr. Chairman, as given against the proposition; because while perhaps at some later period in our work when we get to a point where some special expenditures will be required, as stated in our report, we have only just begun, and there is time enough yet to consider the matter of an outlay necessary at a future time. The action now taken relieves us from any attitude of asking for charity, more especially from organizations that are without the bounds of this Association. We cannot go to anybody but our own members; it would be like asking charity. I think it will be the concensus of opinion of our entire Committee that the action taken was very proper, and that we ourselves very heartily approve it.

Mr. Nourse: Thank you, sir.

Mr. Campbell: Especially since we have gotten Brother Nourse's three dollars.

Adjourned until 9 A. M., June 8th.

Third Day Session—Wednesday, June 8, 1904.

The Convention met pursuant to adjournment, First Vice-President Sherrerd in the chair.

Applications for membership were read by the Secretary, as follows:

ACTIVE.

J. A. Carlson, Water Commissioner, Stromsberg, Neb.

J. M. Deffenbaugh, Water Commissioner, Lincoln, Neb.

Horace E. Horton, Civil Engineer, Chicago, Ill.

On motion of Mr. Rosamond, the Secretary was directed to cast one ballot for the election of the applicants named to active membership, and the Secretary having so done, the Chair announced the election.

Secretary Diven read communications from the following: The Engineering Record Publishing Company, tendering courtesies to members at their headquarters at the Exposition grounds, located in the Electricity Building; from Mr. H. J. Pfeifer, Secretary American Society of Civil Engineers; also correspondence between Mr. F. R. Hutton, Secretary American Society of Mechanical Engineers, and Secretary Diven, with reference to the headquarters for engineering interests in a building proposed to be erected by Mr. Andrew Carnegie.

Without objection, the foregoing were received and filed, and the last named communication was duly referred to the Executive Committee for consideration.

The Secretary also read the following cablegram from Mr. Nicholas P. Simin, of Moscow, Russia, a member of the Association:

ST. LOUIS WATER WORKS CONVENTION:

My best wishes are water for health, water against fire.

NICHOLAS SIMIN.

CHAIRMAN SHERRERD: I am pleased to announce that we have with us this morning Mr. Fr. Frölich, who comes from Germany as a delegate, representing the German engineering societies at the Louisiana Purchase Exposition, and who has honored us by attending our meetings. I would suggest that the privilege of the floor be extended to him.

On motion, the action suggested by the Chair was taken, and Mr. Frölich was asked to address the convention.

MR. FROLICH: Mr. Chairman and Gentlemen, I thank you very kindly for the privilege you have extended me, and for the opportunity of learning something of the scientific work you are doing in this country. I am a mechanical engineer, and as such interested in the building of pumps and thus indirectly in water works. I may, perhaps, call your attention to some of our exhibits in the exposition which are on display in the Liberal Arts Building. You will there find the plans according to which our great reservoirs have been constructed. We have done considerable work in Germany in the last few years in building reservoirs for two purposes principally; first, for water works; secondly, for preventing inundations, especially in Silesia and in Bohemia. You will also find in the German exhibit in the Liberal Arts Building plans and models of several great water works of Germany, especially those of Berlin, Frankfort-on-the-Main, Cologne and others. Perhaps some of your members will be interested in examining them.

Chairman Sherrerd announced the next order of business the reading of papers, and the first paper on the programme, "Modifications of the Plans of the New Croton Dam," by Mr. William R. Hill, was read and discussed by Messrs. F. S. Cook, Beemis, Heeger, Rosamond, Boardman and others.

Second Vice-President Bennett then took the chair and Mr. Sherrerd discussed Mr. Hill's paper.

Mr. J. B. Heim moved that the paper by Mr. Hill be received, spread upon the minutes, and printed in our proceedings, which motion was duly seconded and carried.

Chairman Bennett then announced the next paper on the programme, "Experience with Growths in Water Mains," by Mr. Owen T. Smith, which was read and discussed by Messrs. Charles, Patton, Whipple, Maury and others.

Mr. John W. Alvord's paper, "The Cost of Cast Iron Pipe," was then presented by the writer and briefly explained—the paper being printed in the advance edition, and was discussed by Mr. Gwinn and others.

On motion of Secretary Diven, the paper was ordered received, spread upon the minutes, and printed in the proceedings, and the thanks of the Association extended to Mr. Smith.

On motion duly made and seconded, the same disposition was made of Mr. Alvord's paper, and a vote of thanks extended to him.

ELECTION OF OFFICERS.

Chairman Bennett: The election of officers is now in order. I will name as tellers Messrs. Caulfield and Gwinn. Only active members are qualified and entitled to vote on the election of officers. Nominations for President are now in order.

MR. C. H. CAMPBELL, in a graceful speech, nominated Mr. Benjamin C. Adkins, and Mr. Boardman seconded the nomination.

MR. FELIX placed in nomination Mr. Morris R. Sherrerd, which nomination was seconded by Mr. Nourse.

A ballot being taken, Mr. Sherrerd was declared elected, and on motion of Mr. Campbell the election was made unanimous.

PRESIDENT-ELECT SHERRERD: Gentlemen of the American Water Works Association: I thank you for this great honor that you have to-day conferred upon me. I appreciate it deeply, feeling that it is the greatest honor that I have ever received in the line of my profession.

The American Water Works Association is on the ascendency, and ought to be made stronger and its authority and influence more widely felt throughout the United States. And I want to say as your presiding officer it shall be my endeavor to do what little I can to forward that object, in order that this Association may be great not only in numbers, but in influence and usefulness.

I hardly know how to thank you. It seems unfortunate for the Association that you must be afflicted with the same presiding officer for two years. I will, however, with your help, try to do the best I can to support the hands of our worthy Secretary in forwarding the interests of this Association. I thank you. (Applause.)

SECRETARY DIVEN: Mr. President, I ask unanimous consent that the rules be suspended and I be permitted to cast the unanimous ballot of this Convention for Mr. Benjamin C. Adkins, of St. Louis, for first vice-president.

Seconded by Mr. Ellis and carried unanimously.

The election of Mr. Adkins was duly announced by the Chair.

On motion of Mr. Penny, seconded by Mr. Boardman, the Secretary was directed to cast the unanimous vote of the Convention for the election of Mr. Thomas H. Bennett, of Oswego, N. Y., for second vice-president. The ballot being so cast, the election was announced by the Chair.

On motion of Mr. Wiles, seconded by Mr. Campbell, the Secretary was directed to cast the unanimous vote of the Convention for the election of Mr. Charles E. Rowe, of Dayton, Ohio, for third vice-president. The ballot being so cast, the election was announced by the Chair.

On motion of Mr. Gwinn, duly seconded, the Secretary was directed to cast the unanimous vote of the Convention for the election of Mr. Dabney H. Maury, of Peoria, Illinois, for fourth vice-president. The ballot being so cast, the election was announced by the Chair.

MR. CAMPBELL presented the name of Mr. H. O. Nourse for fifth vice-president, but Mr. Nourse declined, and it being announced that once vice-president had already been elected from his state, the nomination was not considered.

MR. NOURSE then nominated Mr. A. A. Tucker, and Mr. Keeler placed in nomination the name of Mr. Alexander Milne, of St. Catharines, Canada, holding that the Dominion should be represented.

A ballot being taken, Mr. Tucker was declared elected.

On motion of Mr. Kimball, the President was directed to cast one ballot for the Association for J. M. Diven for secretary-treasurer.

MR. SHERRERD accordingly cast the ballot and announced the election of Mr. Diven as secretary-treasurer.

SECRETARY DIVEN: Mr. President and Gentlemen, I heartily thank you, and greatly appreciate this endorsement of the work that I have done, and to show my appreciation still further I will endeavor to do better in the future, as I believe I can. The experience of the last two years has taught me a great deal, and I intend to profit by that and see that the Association has the benefit. It is my ambition to see this Association have not less than one thousand active members. I believe that I shall live to see that day. (Applause.) We have started in the right direction. We are going up. Growth has commenced, a good, solid and healthy growth; and I believe that the next two or three years will see us with not less than one thousand active members, in addition to all of our other membership. (Applause.)

The Chair called for nominations for Finance Committee.

Mr. Campbell nominated Mr. H. E. Keeler of Chicago, Illinois, as Chairman of the Finance Committee.

The motion was seconded by Mr. Bennett, and Mr. Keeler thereupon elected.

Mr. Diven nominated as the second member of the Finance Committee Mr. Alexander Milne, of St. Catharines, Ontario, Canada, who was thereupon duly elected.

Mr. Kimball: I desire to place in nomination as the third member of the Finance Committee a gentleman that I think you and the Executive Committee will endorse as a good worker for the Association, Mr. Robert J. Thomas, of Lowell, Mass.

The nomination was seconded by Mr. Bennett, and Mr. Thomas thereupon duly elected.

The Chair called for nominations for next place of meeting. Secretary Diven read invitations from the following cities, viz.: Atlanta, Ga.; Detroit, Mich.; Milwaukee, Wis.: Ludington, Mich.; West Baden, Ind., and Boston, Mass.

Mr. Campbell championed the cause of Boston, that being, he stated, the city where the first water-works was established. Here the British first took water—at Bunker Hill!

Mr. Kimball read letters from Governor Bates and others, referred to the fact that engineering works of magnitude are now under way there of a character excelled at but few places in this country, and in some of their details not at all.

The New England Water Works Association, while not yet in a position, pending action by this Association, to take definite action, at a recent meeting of their Executive Committee, the desire was expressed that this Association meet in Boston next year, and a joint session favored for at least one day, of the two Associations. Nearly one hundred members of the A. W. W. A. are also members of the New England Water Works Association, thus relating the two Associations very closely. Hotel and other accommodations would be first-class, and a warm welcome awaited all at Boston.

Mr. Bemis spoke for Cleveland, if any Western city was to be the choice of the convention. One of the best equipped pumping stations in the country had just been completed there. The cool lake breezes and ample hotel facilities made it a good convention city. It was now about sixteen years since the Association had honored Cleveland by meeting there.

Mr. Keeler made an enthusiastic plea for West Baden as a place where the best facilities would be afforded, and at prices that would suit the purse of all. The members would be kept together and both the interests of the Association and the supply men consulted. The supply men would not be called on for any expenditures by way of entertainment, and would have a vacation in this respect for the time. West Baden is a point easily accessible, and centrally located. Mr. Keeler went into details on this and other points, and succeeded in awakening a strong sentiment in favor of the city he pleaded for.

MR. HEEGER, of Evansville, followed in a strong speech for Evansville, Ind., promising those who should attend there the time of their lives, an old fashioned "Hoosier" welcome, and "Burgoo" and all accompaniments. Hotel charges would be at a minimum, and ample accommodations on the outside for those who preferred. Those who have experienced Mr. Heeger's hospitality know that it is the real thing. At the conclusion of Mr. Heeger's talk there was a "hurrah for Evansville!"

MR. KEELER was seconded by Mr. Nourse, who referred to West Baden as the genuine "Hub." His objection to Boston was the great distance for the Western members. He urged that the $2.50 a day proposition of West Baden was the best thing in the United States. The hotel management there would leave nothing undone for the comfort of guests. He had been there, and knew whereof he spoke. Delightful air and surroundings, a splendid hall, free music and the natural advantages of the place made a combination that should be irresistible.

MR. THOMAS followed and drove some solid points home for Boston. In addition to the engineering works referred to by a previous speaker, there were within a few miles from Boston many small suburbs and municipalities which afforded opportunity for the inspection of water works plants of every conceivable character, a visit to which by any of the Western members, who might be contemplating the erection of new plants, would certainly prove highly interesting and suggestive. The speaker specified several of these and referred to the City of Lowell, with a population of 100,000, supplied with well water, not an artesian well supply, but water of a hardness of only about 1.3%, a comparatively soft water. Many of these smaller plants had passed through from fifty to a hundred years of existence, during which they had met and overcome many of the obstacles likely to be encountered by similar plants in the West and elsewhere. The delegates might have old Faneuil Hall as a meeting place, in which the voice of some men had not only been distinctly heard to any point in the room but also even to roll down the centuries. (Applause.)

MR. BEMIS: In order to avoid a second ballot, since the convention is evidently going to decide upon Boston, or West Baden, I wish to withdraw the nomination of Cleveland, and shall vote for one or other of those two places myself. It will simplify the balloting.

MR. HEEGER: Being a Hoosier myself, and West Baden being a Hoosier city, I withdraw Evansville in favor of West Baden. (Mr. Heeger, however, made no promises that the delegates would not have to wear dress suits at West Baden, as he did for Evansville.)

MR. JOHN C. KELLY rose to ask whether it was permitted to drink anything else but water at West Baden.

MR. SHERRERD relieved Mr. Kelly's solicitude by stating that if he drank no water he could drink anything else that he chose. (Laughter.)

MR. GWINN, of Indiana, wished to be informed as to hotel rates at Boston.

MR. KIMBALL stated that Boston was pre-eminently a convention city, probably more such meetings being held there than in any other city in the United States. Accommodations could be secured at almost any figure desired. At the Back Bay hotels, in the prettiest sections of the city, where convention halls and committee rooms would be furnished without charge, the rates were from $3.00 to $5.00 a day, the lower price securing as good accommodations as need be desired, but if extra trimmings were wanted a higher price was asked. Rooms on European plan from $1.00 to $3.00 a day.

A ballot was now taken, with the following resules: Boston, 52; West Baden, 79.

West Baden, Ind., was declared the choice.

PRESIDENT SHERRERD: I would like to bring to the attention of the convention a suggestion that I think would be worth considering in regard to holding conventions. I believe that it would be a good plan to charter one of the large lake steamers, one that will give rates for a trip at so much a day, including stateroom and meals. We could arrange for a four or five day trip, I believe, on a basis of from $4.00 to $5.00 a day, covering all our expenses, stopping at different lake cities, and by prearrangement visit the different water works plants. This matter has been somewhat considered by the American Society of Civil Engineers. and I would commend its serious consideration for a future convention.

MR. W. R. HILL called the attention of the convention to the very fine exhibit of over two hundred photographs showing the Croton aqueduct construction, on display by the New York Water Department, in the New York State Building, at the World's Fair.

After announcement of the entertainment features of the day, including a river excursion on the steamer "Corwin Spencer" for the afternoon, and a special entertainment by Hale's Fire Fighters, World's Fair Grounds, at 7:30 p. m., the convention adjourned to 9 a. m., Thursday, June 9, 1904.

FOURTH DAY SESSION—THURSDAY, JUNE 9, 1904.

The convention met pursuant to adjournment, President Sherrerd in the chair.

The session was begun in the Committee Room at the Jefferson Hotel; which room had been kindly tendered to the association by the National Brewers' Association.

A paper by Mr. Dabney H. Maury, illustrated by lantern slides, was read and discussed by Mr. Goodell, Mr. Alvord, Mr. Boardman, Mr. Gwinn. Mr. Goodell concluded his remarks by offering a vote of thanks to Mr. Maury for his very able and interesting paper, which motion was seconded by other speakers and being put by the chairman was duly carried.

PRESIDENT SHERRERD: I would like to say that we are indebted to the gentlemen of the United States Brewers' Association for the temporary use of this committee room this morning. They had a reservation on it, which they relinquished in our favor. I would suggest that we take some action acknowledging the courtesy.

On motion, a vote of thanks was extended to the United States Brewers' Association for their courteous tender of the hotel committee room for the use of the American Water Works Association this morning.

After the reading and discussion of Mr. Maury's paper the convention repaired to the regular convention hall, where the business was resumed.

PRESIDENT SHERRERD: Gentlemen, I would like to announce the receipt of a telegram from President Case, thanking the association for its expression of sympathy and regretting his inability to be with us.

Before taking up the regular program, if there is any incidental business requiring attention, the Chair will entertain it.

The secretary read an application for active membership by Mr. Frederick C. Binder, assistant superintendent and treasurer Jefferson City Water Works Co., Jefferson City, Mo.

On motion of Mr. Heim Mr. Bender was elected to membership.

PRESIDENT SHERRERD announced the next order of business the reading of papers, and papers were read as follows:

"Meters, Their Use and Benefit," by Mr. Park Woodward.

"The Meter System in Cleveland, Ohio," by Prof. Bemis.

These papers were both printed in the advance papers, and Mr. Woodward not being present his paper was read by title, and Prof. Bemis gave a synopsis of his. They were then discussed together, being on the same subject. The discussion was entered into by Messrs. Alvord, Bemis, Charles, Ford, Beardsley, Houston, O'Shaughnessy, Patton and Vice-President Rowe.

Vice-President Rowe: in the chair.

Fifth Day's Session—Friday, June 10, 1904.

Convention called to order by President Sherrerd, pursuant to adjournment, and the reading of the papers not reached at yesterday's session taken up, as follows:

"Meter Rates," by Mr. John B. Heim.

"The Equity of a Minimum Charge for Metered Services," by Mr. Frank C. Kimball.

The above two papers were read and discussed together; Messrs. Benzenberg, Heim, Patton, Kimball and others, and the Registrar of the Milwaukee Water Department, by letter, entering into the discussion.

During and as a part of this discussion the committee on "Standard for Water Rates" made its report. Which after remarks by and on motion of Mr. Kimball was accepted.

The President then called up the report of the committee on "Uniform Classification of Accounts," and Mr. Gwinn, of the committee, presented a paper accompanied by many forms.

Mr. Rowe, of this committee, also made a verbal report; the sense of the committee and of the convention seemed to be that it would be almost impossible to establish uniform accounts.

President Sherrerd suggested that the work of the committee be modified, by having them work out a uniform blank for annual reports.

Mr. Bemis sustained this suggestion and made and put it as a motion, which was carried, and the name of the committee was changed to "Committee on Uniform Annual Reports."

PRESIDENT SHERRERD: We are rather behind on our program, and I would like to see if we cannot clear the calendar a little bit. We have next in order a paper by Mr. John C. Trautwine, Jr., C. E., of Philadelphia, Pa., entitled "Resistance Due to Bends in Pipe—Application of Existing Formulas to a Given Case." I understand that this paper is in print, but the author is not here at the convention, nor have the printed copies been received. If there is no objection it will be referred to the Publication Committee and printed in the Proceedings if approved by it.

MR. GWINN: I would suggest that it might be mailed in print to members so that they could comment on it by way of discussion.

PRESIDENT SHERRERD: If there are sufficient number of copies, they will be mailed to the members.

The paper took the course suggested by the Chair.

PRESIDENT SHERRERD: We have also a paper entitled "Resume of Investigation Respecting Water Hammer," by O. Simin. This paper has been printed and distributed. The matter was furnished by Miss Olga Simin, daughter of a prominent water works man in Russia. It is accompanied by several diagrams—rather intricate paper, and I think a very important one. With your permission it will be referred to the Publication Committee, and, if approved by them, be printed in the Proceedings.

The Secretary read at the request of the President, the paper by Mr. L. N. Case, entitled "Private Fire Systems," and the same was referred to the Publication Committee.

The paper by Mr. Alfred M. Quick, entitled "Water Service at the Baltimore Fire," having been printed in the advance copy, was read by title.

PRESIDENT SHERRERD: I had hoped that Mr. Quick would be here. Is there any discussion? If not we will take up the report of the Committee on Constitution and

By-Laws. President Case, the chairman of that committee, is not present, but Mr. Frailey and Secretary Diven, the other members of the committee are. I would say that the Committee formulated some modifications of the Constitution, which in accordance with the present constitution were submitted to, and have been considered by, the Executive Committee, section by section, and approved with slight modifications from the Committee report. The Secretary will now present that report as formally approved and recommended to the Association by the Executive Committee.

The proposed constitution was then read by sections by the Secretary and each section acted upon separately.

PROPOSED CONSTITUTION.

ARTICLE I.

Section I. The name of this association shall be THE AMERICAN WATER WORKS ASSOCIATION.

ARTICLE II.

OBJECT.

SECTION I. *The object shall be the advancement of knowledge of public water supply, furnished either by public or private ownership and the management of water works;* the exchange of information pertaining to the management of water works and water supply, for the mutual advancement of the interests of consumers and suppliers, and for the purpose of securing economy and uniformity in operation; the establishment and maintenance of a spirit of fraternity among its members by social intercourse and friendly exchange of information and experiences; *and the bringing into closer and more harmonious relations the manufacturer of water works supplies and water works managers.*

ARTICLE III.

MEMBERSHIP.

SECTION 1. The members of this association shall consist of three Grades: Honorary Members, Active Members *of two classes, viz.: individual and corporate* and Associate Members.

SECTION 2. Honorary Members shall be those whose scientific or practical knowledge in matters relating to *public* water supply, and whose efforts and interests in that behalf shall recommend them to the association. They shall be entitled to the same privileges as associate members, but shall not be required to make any payments for the support of the association.

SECTION 3. Individual Active Members shall be those managers or superintendents of water works, *members of water boards or water commissioners; directors of water companies; Civil, Mechanical or Hydraulic Engineers; Sanitary Engineers or Experts or other persons qualified to and actually engaged in the advancement of knowledge relating to public Water Supply,* as may make personal application, pay the required initiation fee and annual dues and be elected to membership.

Corporate Active Members shall be those Water Commissioners, members of water boards or officers of Municipal Water Works or Directors or Officers of Water Companies who at the time hold office; the name of such member to be changed on the roll and books of the association to that of his successor in office when his term of office shall expire, or for any other reason the office is changed. Corporate Active Members shall have all of the rights and privileges of Indivadual Active Members during their incumbency in office, and when their successor is named may, without re-election or payment of initiation fee retain their membership and be classed as Individual Active Members.

SECTION 4. Associate Members shall be such persons, firms or *corporations* engaged in manufacturing or furnishing materials and supplies for the construction and maintenance of Water Works as may apply for admission and be approved by the executive committee, or by the Association at a regular meeting.

Associate Members shall be entitled to one representative *on the floor* at each meeting, who shall have all of the privileges of active members, except voting for election of officers, *and no associate member shall be permitted, except by unanimous consent, to engage in any debate or discussion, or to present a paper on any subject directly appertaining to the business in which he is engaged or represents.*

SECTION 5. Water Departments or Water Companies may be received as Associate Members, to be governed by the provisions of Section 4.

SECTION 6. When an Active Member so changes his vocation that were he to apply for membership he would be classed as an Associate Member, he may continue as an Active Member with all of the privileges of that class, except that he shall not be eligible to any office in the association, while thus engaged.

ARTICLE IV.

ADMISSIONS AND EXPULSIONS.

SECTION 1. *Each application for membership shall be made on blank forms prescribed by the association* and shall state the applicants name and address, office held in a water department or company, or profession or business *and shall embody a concise statement of the applicant's qualifications for membership, and shall be endorsed by one Active Member.*

SECTION 2. *Applications for membership shall be presented to the executive committee, who shall consider them, and if approved present them to the association* *for ballot at the next stated meeting.*

SECTION 3. Election to membership shall be by ballot and shall require the affirmative vote of two-thirds of the ballots cast.

SECTION 4. Any member whose dues are in arrears for three years at the beginning of the fiscal year shall be notified to that effect, and if payment is not made within sixty days after such notice is mailed to their last known address, they stand suspended. It shall be the duty of the Secretary to notify them of their suspension, and their names shall be dropped from the roll of members.

SECTION 5. Any member who has been suspended for non-payment of dues may, if he applies within one year from date of his suspension, be reinstated *by the executive committee,* upon payment of all back dues.

SECTION 6. *A member of any grade may be expelled from the association for cause, upon the recommendation of the executive committee, adopted by a two-thirds vote of the members at any annual convention.*

SECTION 7. Any member may retire from membership by giving written notice to that effect to the Secretary and the payment of all annual dues to that date, unless released from said payment by the executive committee.

ARTICLE V.

FEES AND DUES.

SECTION 1. *Individual* Active Members shall pay an admission fee of five dollars, which *together with the first year's dues* must accompany the application. The annual dues shall be three dollars, payable annually in advance.

SECTION 2. *Corporate Active Members shall pay an admission fee of ten dollars, which together with the first year's dues must accompany* the application; the annual dues shall be three dollars, payable annually in advance.

SECTION 3. Associate Members shall pay an admission fee of ten dollars, which, *together with the first year's dues*, must accompany the application; the annual dues shall be ten dollars, payable annually in advance.

SECTION 4. *The annual dues shall became due for the ensuing year on the fifteenth day of April, and shall be payable in advance. It shall be the duty of the Secretary to notify each member of the amount due for the ensuing year on or before the first day of April.*

SECTION 5. *The annual dues shall commence from the time that the application is made; persons elected whose application is filed after the fifteenth day of October shall pay one-half of the amount of dues for that fiscal year, unless the convention shall be held between that date and the beginning of the next fiscal year, in which case the whole amount shall be due and payable.*

SECTION 6. *In case an application is rejected the admission fee and annual dues paid shall be refunded.*

ARTICLE VI.

OFFICERS.

SECTION 1. The officers of this association shall consist of a President, five Vice-Presidents—who shall be respectively residents of different States—a Secretary-Treasurer and a Finance Committee consisting of three members, to be elected annually by ballot.

SECTION 2. The Executive Committee shall be composed of the officers of the association as provided for in Section 1, together with the President or Acting President for the preceding year.

SECTION 3. *A vacancy in the office of President shall be filled by the senior Vice-President. In case of a vacancy in the office of* Secretary-Treasurer the *Executive Committee* shall appoint a successor to hold office till the next annual election.

ARTICLE VII.

DUTIES OF OFFICERS.

SECTION 1. *The President shall have a general supervision of the affairs of the association.* He shall preside at all meetings of the association and executive committee at which he may be present, *and he shall deliver an address at the annual convention.*

SECTION 2. The Executive Committee shall have full control of the management of the affairs of the association, subject to the control of the association assembled in regular convention. *They shall make the necessary arrangements for the conventions and shall have power to expend the funds of the association or to invest the same, but must not incur any indebtedness beyond the funds in the hands of the Secretary-Treasurer.* The Executive Committee shall hold meetings at the call of the President or in his absence the Senior Vice-President; and shall hold an annual meeting at least one hour before the opening of the first session of the annual convention.

All questions in the Executive Committee shall be decided by majority vote, and five members shall constitute a quorum.

The Executive Committee may vote by letter upon questions submitted by the President or Secretary-Treasurer.

SECTION 3. The Secretary-Treasurer *shall be an active member of the association. It shall be his duty to attend all conventions and meetings of the Association and Executive Committee; prepare the business and duly record the proceedings thereof.* He shall see that all monies due the Association are carefully collected. He shall personally certify the accuracy of all bills or vouchers on which money is to be paid.

He shall have charge of the books of the Association, and shall make a report of the receipts and expenditure and of the condition and affairs of the Association at the annual convention.

He shall have printed and distributed to all members a copy of the proceedings of the annual convention, and shall perform all other duties assigned him by the Executive Committee.

He shall conduct the correspondence of the Association *and keep a full record of the same.* For his services he shall receive such compensation as the Executive Committee may determine, *and he shall give a surety bond, the expense thereof to be borne by the Association, in such sum as the Executive Committee may determine and fix from year to year.*

SECTION 4. The Finance Committee shall meet on the first day of each annual convention, at least one hour before the opening session to receive from the Secretary-Treasurer a statement of his accounts and audit the same. They shall examine the books of the Secretary-Treasurer, and shall hold such other meetings as the interests of the Association require.

ARTICLE VIII.

NOMINATION AND ELECTION OF OFFICERS.

SECTION 1. The President shall not be eligible for immediate re-election, except by unanimous vote.

SECTION 2. The Association shall at the first session of the second day of the annual convention nominate from the floor of the convention candidates for all of its elective officers who shall thereafter be elected by ballot, those receiving the highest number of ballots for the respective offices shall be declared duly elected for the coming year, *and shall assume their respective offices immediately after the final adjournment of the convention at which they are elected.*

ARTICLE IX.

MEETINGS.

SECTION 1. The annual convention of the Association shall open on the third Tuesday in April of each year, at 10 o'clock a. m., at such place as shall be designated by the Association at the previous convention; *the selection to be by ballot, the place receiving a majority of all of the votes cast to be selected as the place of meeting, and all grades of membership shall be entitled to vote.* The Executive Committee, however, shall have power to change the date *and place* of meeting, as in its judgment the interests of the Association may demand.

ARTICLE X.

PUBLICATION COMMITTEE.

SECTION 1. All papers presented to the Association must be either printed, typewritten or in plain handwriting, and be in the hands of the Secretary at least *thirty* days prior to the annual convention; who shall submit them to the Publication Committee for their examination and acceptance *or rejection,* and in case the said committee fails to act upon them within a reasonable time then they shall be subject to Section 2 of this article.

And the Secretary shall as soon as practicable after action on a paper by the Publication Committee, send advance copies to all members of the Association.

SECTION 2. If any paper is too late for critical examination by the Publication Committee, said paper may be so far passed upon by the *Secretary* as to allow its reading, but such paper shall not be published in the Proceedings without the approval of the Publication Committee.

SECTION 3. All papers accepted by the Association, whether read in full, by abstract, by title or filed shall be delivered to the Secretary as soon as thus presented. Any paper presented to the Association and accepted by it shall be refused publication in the Proceedings of the Association if it be published, in whole or in part, by permission or assent of its author, *in the public press,* prior to presentation to the convention.

SECTION 4. The Publication Committee, charged with the duties of selecting *the matter to be printed in* the Proceedings of the Association, shall consist of five active members, one of whom shall be the Secretary, appointed by the President, and the President shall have power to fill vacancies. Three members of the committee shall constitute a quorum.

SECTION 5. All papers read by title and others not definitely passed upon by the *Secretary,* shall be referred to the Publication Committee for critical examination; and said committee is authorized to reject such papers as in its judgment are not of general interest to the Association and to omit such others as in its judgment should not be published.

SECTION 6. The stenographer's notes of the discussions shall not be furnished for publication or published in the Proceedings until they have been submitted for correction to the persons taking part in the discussion and a reasonable time allowed for their return, and all members shall be permitted at any time within *twenty* days after any convention to submit written discussion on any paper or subject presented, read or discussed at that convention, and such discussion shall be submitted to the author of the paper under discussion or to the maker of the remarks or discussion to which it applies, for his answer, which shall be published in the Proceedings and be final. *But a paper in answer to or criticising one read at a convention may be presented at a future convention.*

SECTION 7. This Association shall not be responsible, as a body, for the facts or opinions advanced in any of the papers or discussions published in its Proceedings.

ARTICLE XI.

GENERAL.

SECTION 1. Any member may, with the concurrence of the presiding officer, admit friends to the meetings of the Association, but such person shall not take part in the discussions without the consent of the convention; *and the privilege of the floor can only be granted to a non-member by unanimous consent.*

SECTION 2. The Secretary shall send notice to all members of the Association at least fifteen days before the annual convention, giving the titles of papers to be read and mentioning any special business to be considered at said convention.

ARTICLE XII.

ORDER OF BUSINESS.

SECTION 1. At the annual conventions of the Association the order of business shall be:

1st. Call of Roll.
2nd. Reading of minutes of last convention.
3rd. Reading of applications for membership.
4th. Election of members.
5th. The address of the President.
6th. Report of the Executive Committee.
7th. Report of the Secretary-Treasurer.
8th. Report of the Finance Committee.
9th. Report of Standing and Special Committees.
10th. Reading of papers for discussion.
11th. Election of officers.
12th. Selection of place for holding next convention.
13th. General business.

ARTICLE XIII.

AMENDMENTS.

SECTION 1. All propositions for adding to or altering any of the provisions of the foregoing Constitution shall be submitted to the Executive Committee, who may bring it before the next general convention of the Association at its discretion, and such committee must do so on the requisition in writing of five members of the Association.

SECTION 2. Each member of the Association shall, upon request, be furnished by the Secretary with a copy of the constitution of the Association, and, also, a list of the names and residences of its members.

NOTE: Matter in italics is new.

NOTE: Articles III. and IX. were adopted as amended and are now part of the Constitution.

MR. GWINN moved to amend the report with respect to the provisions regarding the Executive Committee, so as to make Past Presidents retaining a membership in the Association ex-officio members of the Executive Committee, with a right to vote when present at conventions, but not to be counted in making a quorum at Executive Committee meetings. After considerable discussion, participated in by Messrs. Thomas, Goodell, Kimball, Heim, Neville and O'Shaughnessy, Mr. Gwinn's motion was not concurred in. The consensus of opinion was that the committee if so constituted would be unwieldy, a similar plan having been tried in other societies and found objectionable.

MR. O'SHAUGHNESSY called attention to the fact that no provision had been inserted in the proposed modifications requiring the secretary-treasurer to give a bond in a sum to be fixed by the Executive Committee.

On motion the report of the Committee on Constitution and By-Laws was amended so as to contain such a recommendation.

At the instance and suggestion of Secretary Diven the recommendation as to creating a new membership class was adopted at this time as an amendment to the present Constitution and By-Laws, Secretary Diven believing that such a provision will aid in securing many new members.

It appearing that a sufficient number of members were not in attendance to represent the entire body of membership with respect to amending the Constitution, although a quorum was present, after some discussion, motions and amendments, Mr. Kimball offered as a substitute for the whole the following:

MR. KIMBALL: I would move, therefore, that so much of the report of the committee as relates to membership be adopted as a part of the Constitution, subject to such further amendment at the next meeting as may be desirable; and that the report as a whole be printed and distributed to the members when the Proceedings are distributed, to be acted upon at the next meeting of the convention.

The motion was seconded by Mr. Gwinn.

MR. NEVILLE: The definite matter that I had in mind was to consider the expense of printing leaflets or pamphlets; that that be incorporated in the Annual Report, and then leaflets could be prepared for distribution from the same matter by the printer, and sent out to the members.

PRESIDENT SHERRERD: It has been moved and seconded as a substitute that the Constitution and By-Laws as submitted by the Executive Committee be adopted as far as it relates to membership; the balance of the report to be printed in the Proceedings and submitted for final action at the next convention.

Motion put and carried.

PRESIDENT SHERRERD: We have not as yet received the report of the Committee on Standard Specifications for Cast Iron Water Pipe. The chairman of that committee, Mr. Croes, telegraphed to the secretary that the report had been mailed. We have been trying to locate it, but without success. I understand that the report has been considered by two members of the committee, and as formulated by the chairman was approved by one other member, but has not as yet been signed by the third member of the committee. I would like the consent of the convention to have this report submitted to the Executive Committee, and if approved by them printed in the proceedings. Mr. Benzenberg, the other member of the committee, is present, and we would like to hear from him.

MR. BENZENBERG: This matter I take a great deal of interest in, as stated a year ago. I had hoped that amended specifications would be submitted by the committee. The committee could not arrange for a meeting, and their opinions and views have been sent by correspondence. I have not heard from the chairman of the committee and have not yet seen the report.

MR. KENNEDY: I move that Mr. Benzenberg have the opportunity to make out a minority report.

MR. O'SHAUGHNESSY: I would suggest that if we are to have a meeting to-morrow morning, as programmed, why not wait and see if the report will not be received in the mails?

On motion of Mr. Gwinn, the matter was passed until to-morrow morning.

SECRETARY DIVEN read the report of the Committee on Publication, which, on motion of Mr. Neville, was received and approved as read, as follows:

REPORT OF PUBLICATION COMMITTEE.

ST. LOUIS, MO., June 10, 1904.

To the Officers and Members of the American Water Works Association.

Gentlemen: Your committee would report that they have carefully examined all of the papers which have been presented for this convention and approve all. We are pleased also to report that the character and quality of these papers is of a high grade, and the Association is to be congratulated on the improvement made in its effort to secure and furnish its members with advance copies of its papers.

Respectfully submitted,
H. E. KEELER,
H. O. NOURSE,
DABNEY H. MAURY,
J. M. DIVEN.

PRESIDENT SHERRERD: There are two papers still remaining on the programme for to-day, "Looking Backward," by William Lociel Cameron, the other, "Reminiscences and History of the American Water Works Association," by L. H. Gardner and J. M. Diven. These two papers are of a similar nature. Mr. Cameron's paper is here, but the gentleman himself is not present.

On motion the above papers were considered as read, and referred to the Publication Committee.

PRESIDENT SHERRERD: I would like to say that the secretary and myself have consulted as to the personnel of the standing committees for the ensuing year, and at his suggestion we telegraphed to President Case, from whom we have received the following telegram: "Sherrerd will announce committees, of course. L. N. Case." In accordance with that instruction I will now announce the standing and special committees for the coming year, as follows:

STANDING AND SPECIAL COMMITTEES.

PUBLICATION COMMITTEE.

H. E. Keeler, Chairman, 97 S. Clinton Street, Chicago, Ill.

D. W. Mead, Consulting Engineer, First National Bank Building, Chicago, Ill.

Dabney H. Maury, Engineer Water Works Co., Peoria, Ill.

John W. Alvord, Consulting Engineer, Chicago, Ill.

J. M. Diven, Secretary, ex-officio, Elmira, N. Y.

ELECTROLYSIS.

Dabney H. Maury, Chairman, Engineer Water Works Co., Peoria, Ill.

G. H. Benzenberg, Consulting Engineer, Milwaukee, Wis.

J. Waldo Smith, Chief Engineer Aqueduct Commission, New York, N. Y.

STANDARD SPECIFICATIONS FOR CAST IRON WATER PIPE.

J. J. R. Croes, Consulting Engineer, New York, N. Y.

G. H. Benzenberg, Consulting Engineer, Milwaukee, Wis.

Stephen E. Babcock, Consulting Engineer, Utica, N. Y.

UNIFORM ANNUAL REPORTS.

John Caulfield, Chairman, Secretary Water Works, St. Paul, Minn.

Charles E. Rowe, Secretary Water Works, Dayton, O.

Jerry O'Shaughnessy, Water Department, Columbus, O.

John A. Affleck, Water Commissioner, Harrisburg, Pa.

John F. Sprenkel, General Manager York Water Co., York, Pa.

INSURANCE AND SPECIAL FIRE SERVICE SUPPLIES.

C. H. Campbell, Chairman, Superintendent Water Works, Charlotte, N. C.

F. W. Shepperd, Bennett Building, New York, N. Y.

A. E. Boardman, Consulting Engineer, 44 Broad St., New York, N. Y.

George H. Felix, Gen. Mgr. Water Dept., Reading, Pa.

J. H. Purdy, Superintendent American Water Works and Guarantee Co., Pittsburg, Pa.

M. R. Sherrerd, Engineer and Superintendent Water Works, Newark, N. J.

Robert J. Thomas, Superintendent Water Works, Lowell, Mass.

PAST PRESIDENTS' BADGE (SPECIAL).

L. N. Case, Chairman, Manager Water Light Department, Duluth, Minn.

T. R. Cook, Superintendent Water Works, Toledo, O.

E. L. Peene, Superintendent Water Works, Yonkers, N. Y.

EXHIBITS.

Fred Mueller, Chairman, H. Mueller Mfg. Co., Decatur, Ill.

John Strackbein, A. P. Smith Mfg. Co., Newark, N. J.

Octavius Jones, Ludlow Valve Mfg. Co., Chicago, Ill.

Thomas E. Dwyer, Lead Lined Iron Pipe Co., Wakefield, Mass.

Samuel Harrison, H. R. Worthington Meter Department.

ENTERTAINMENT.

F. J. Bradley, National Meter Co., Chairman.

H. O. Nourse, Superintendent Bureau of Water, Chicago, Ill.

J. M. Goodell, Hydraulic Engineer, 114 Liberty Street, New York, N. Y.

J. P. Dennison, N. Y. Continental Jewell Filtration Co., Chicago, Ill.

A. H. McAlpine, General Western Agent Hersey Mfg. Co., 426 High St., Columbus, O.

President Sherrerd: The arrangements for the next convention will, in accordance with the constitution, be in the hands of the Executive Committee. The secretary informs me that there are several volunteer papers covering some important subjects; these will be considered in connection with to-morrow morning's program.

I am requested to announce that the St. Louis Flushing Machine Company will give an exhibition of their flushing machines on Thirteenth street, in front of this hall, immediately upon the adjournment of this session.

Unless there is some special business, the Chair will entertain a motion to adjourn.

On motion, adjourned to 9 a. m., Saturday, June 11, 1904.

SIXTH DAY—SATURDAY, JUNE 11, 1904.

The convention met pursuant to adjournment, President Sherrerd in the chair.

The Secretary read a communication from Mr. H. V. Huse, acting secretary of the United States Brewers' Association, acknowledging the receipt of notification of the action taken by the Association on yesterday in the vote of thanks tendered to the United States Brewers' Association. Mr. Huse stated that it was a pleasure to accord the courtesy referred to.

PRESIDENT SHERRERD: We will now take up the report of the special committee on Standard Specifications for Cast Iron Water Pipe. We will be glad to hear from Mr. Benzenberg, who as the only member of the committee present will read the report in lieu of the chairman, Mr. J. J. R. Croes.

MR. BENZENBERG: I received the report of the committee from Mr. Croes this morning. I also received a telegram from Mr. Stephen E. Babcock, the other member of the committee, authorizing me to affix his signature to the report, he having approved of the same.

I will now present the report.

REPORT OF THE COMMITTEE ON STANDARD SPECIFICATIONS FOR CAST IRON PIPE.

June 4, 1904.

To the American Water Works Association.

Your Committee on Standard Specifications for Cast Iron Pipe report that in the consideration of the subject of the minimum standard of quality of iron permitted to be used in pipe castings, they have been delayed by the neglect of some of the prominent manufacturers of pipe to define precisely the quality of metal which they are prepared to accept as a minimum requirement.

The New England Water Works Association Specifications require that test bars shall support a load of 1,900 pounds and show a deflection of not less than .30 inch before breaking. No other physical test of the metal is called for. In the report of the Committee which framed these specifications it is stated that they had assumed the tensile strength of the iron to be 16.500 pounds per square inch.

The manufacturers who use Southern and Western iron assert their ability to furnish iron of 18,000 pounds tensile strength, but state that test bars of their iron will not come up to the standard named by the N. E. W. W. specification, and they ask that the requirement be reduced to the support of a load of 1,800 pounds with a deflection of not less than .30 inch.

This whole subject was very thoroughly discussed by the New England Water Works Association before their specifications were adopted. The committee first proposed a load of 2,000 pounds. The foundry committee, then as now, asked for an 1,800 pound load, but after all parties had been heard the standard of 1,900 pounds was unanimously adopted and has been accepted by all but a few recalcitrants. Your Committee is of the opinion that it is inexpedient at present for the American Water Works Association to place itself on record as approving either one of these standards. Further opportunity should be given for explanation of the reasons why the N. E. W. W. specifications prescribe less thickness and weight for pipes computed for iron of 16,000 pounds tensile strength, and demand a higher cross breaking strength than the manufacturers desire to prescribe for iron of 18,000 pounds tensile strength with a lower cross breaking standard.

Further consideration and discussion are needed also to determine whether it will not be desirable to reduce the number of classes of pipe called for in the N. E. W. W. specifications. There are ten different classes of pipe specified. For each size of pipe seven classes of weights and thicknesses are called for, involving the keeping in stock by the foundry of a great number of patterns to suit the wishes of customers as to the head under which the pipes are to be used. The weight of any pipe may vary four per cent. either way from the standard, and moreover in computing the required thickness of the metal, the supposed head is more than doubled for security against ram and then the thickness is made five times as great as the breaking strain would demand. It seems unnecessary to require so many kinds of patterns to be kept on hand merely to enable the purchaser of a lot of pipe to select what he guesses will come the nearest to the ordinary conditions of pressure in his pipe system. Four classes of weights suited to heads varying by 100 feet at a class would be more practical and economical for all parties.

If in addition a tensile test be required of the iron used and the castings marked accordingly, A-18, A-20, B-18, B-20, according as the iron showed a tensile strength of 18,000, 20.000, or more, pounds per square inch, pipe of the same class and weight, made of the higher grade of iron could be used for higher pressures than those of the classes in which a lower grade of iron was used.

A table and diagram of weights and pressures attached to and forming part of the specifications would enable the purchaser to select the class of pipe he desired, in accordance with the quality of the iron which the manufacturer was able to furnish.

The specifications put forth by the N. E. W. W. Association and also those suggested by the manufacturers are defective as regards the provisions for the coating of the pipe.

Your Committee recommend that Sect. 12 of the N. E. W. W. Association be made to read:

Sec. 12. The pipes and special castings shall be thoroughly cleaned with both hard and soft brushes to remove all adhering sand, clay and dust and subjected to a careful hammer inspection. If required by the purchaser, the exterior and interior surfaces of the pipes and special castings shall be thoroughly cleaned by the use of a sand blast, at a specified price per ton.

Sec. 13. Every pipe and special casting shall be coated inside and out with a coal tar varnish composed of 5 per cent. of resin and 95 per cent. of the best coal tar, distilled at a temperature of 440 degrees Fahr. evaporating all the lighter oils and retaining the heavy oils. The coating shall be smooth, tough and tenacious when cold, and free from blisters and bubbles.

The last three paragraphs of this section to be the same as in the N. E. W. W. specification.

Your Committee ask to be continued and instructed to prepare a standard form of specification which they can recommend to the Association, and to this end they invite suggestions and discussion on the points presented in this report.

It is very desirable that uniformity of practice should prevail in the requirements for pipe manufacture and at the same time latitude be allowed for improvements, the main requirements being that nothing less than certain standards of excellence in quality of material, corresponding thickness and weight of castings and mode of coating, should be recognized as permissible in manufacture or in use.

Respectfully submitted,

J. J. R. Croes,
G. H. Benzenberg,
S. E. Babcock,
Committee.

MR. BENZENBERG: I wish to say that the report was drawn up by Mr. Croes, the chairman, and I had not any opportunity to read it until this morning; but it fully corresponds with my view in regard to the matter, that there should be some latitude given in the specifications which are adopted by any association, and that the tables should include such information as will indicate to the Water Works man or engineer upon what basis the thicknesses of pipe are computed, so that he himself may act as judge upon the specifications as meeting the requirements that he may want to place upon the pipe. As they are now, there is nothing in the New England Water Works specifications that will indicate what the tensile strength of the metal is assumed to be or what was assumed by the committee, or whether the quality of the metal is a minimum or a maximum standard. It seems to me that they should contain at least something which would indicate to the man who is to use them what they are supposed to represent.

PRESIDENT SHERRERD: You have heard the report, gentlemen. I think it would be well to act on the suggestion that the committee be continued, and if they can agree upon the form of specifications which they are willing to recommend to the Association, that that form of specification be submitted to the secretary for distribution in a separate pamphlet and be published in the Proceedings of this convention, to be considered by the Association at large, for adoption at the next convention. I understand there is also a committee of the pipe founders, and I presume that our committee will confer with them. We would like to have the specifications provide for something that the founders can reasonably meet. What will you do with the report of the committee?

MR. ROSAMOND: I move that the report of the committee be adopted, the committee continued, and the recommendations contained in their report carried out. Seconded.

MR. KIMBALL: There is only one suggestion I would make in this connection, which undoubtedly the committee will attend to, and that is this: The New England Association have adopted quite an extensive and well set out set of specifications. These are used now very largely, not only in New England, but by engineers in other portions of the country; and it would be somewhat confusing to have two standard sets of specifications, if it is possible to have only one. I have not the slightest doubt but that the New England Association would be very glad to have a conference by committee with our committee, and make such changes in their specifications as the joint judgment of the two committees might determine. I would suggest, therefore—I will not do it in the form of a motion, because it is all within the power of the committee—I would suggest that the committee communicate with the New England Association with a view to standardizing the standards; in other words, of having one set of specifications rather than to have two, which would be confusing.

PRESIDENT SHERRERD: Mr. Wood is with us. If there is no objection we will be glad to hear from him upon the founders' side of this question.

MR. WOOD: Gentlemen, there is not very much to add to what has been said. I am going to ask our president to excuse me, if I refer to his speaking of a "foundryman's side of the question." I do not think that the foundry men feel that there are any "sides." What is contemplated is a united effort to get such uniformity in specifications as will permit the founders keeping in stock pipe of a standard which will be satisfactory to the engineers, and thus enable pipe to be made more cheaply because made continuously, and also to permit the purchaser to secure his pipe readily and promptly. There is one further thought I want to speak of, and that is this: In the discussions that have taken place on this subject the aim has not been to have specifications from which there will be no departure, the thought being that if you attempt to make cast iron rules—I mean to fix a standard—which is not to be departed from under any contingencies, you limit and control the growth and development of engineering progress and hence you also limit the growth and development of the manufacturer. Any engineer who from his surroundings has to meet special requirements and wishes from engineering reasons to prepare his own specifications, should feel entirely at liberty to do so; and the manufacturer should feel entirely ready to meet them. It is only by having elasticity that you are ever going to get progress, and progress is the keynote of an Association of this kind.

In saying this it may seem that I am cutting the ground from under "standard specifications"; but I do not think I am, because the whole thought of "standard specifications" such as we are talking about is to get a quality of product which will be safe for a man to buy without troubling himself with details. In other words, the buyer will always have the opportunity of being certain of the character of the materials that he is handling and the manufacturer will always be certain he is making something which will meet the judgment of the best engineering skill of the trade as to its desirability and uniformity. Whatever specifications are adopted should have the stamp of approval of all those in the business. I think it is only wise to sit down and confer that we may arrive at conclusions which we will all be satisfied with and which will be a uniform basis from which the average demands of the country shall be supplied.

PRESIDENT SHERRERD: If there is no objection, we will also be glad to hear from Mr. Lemoyne.

MR. LEMOYNE: I have very little to add to what has been said. The United States Cast Iron Pipe & Foundry Co., which I represent, would be very glad to confer with your Committee. We are only too anxious to have a uniform standard of practice. I think I might say as a member of the Founders' Committee, that in conference with the New England Association the question of standards has already been thrashed out pretty thoroughly. There is very little difference between your committee and the founders to-day. I hope the committee will be continued, and that you will grant the manufacturers a chance to present their side.

PRESIDENT SHERRERD: Does the original mover agree to incorporate in his motion the suggestion that the committee confer with the committee of the New England Water Works Association?

MR. ROSAMOND: That is my desire.

PRESIDENT SHERRERD: It is moved and seconded that the Committee on Standard Specifications for Cast Iron Water Pipe be continued, and requested to confer with the New England Water Works Association Committee on this subject, and also with the representatives of the Founders; and if the committee can agree upon specifications it recommends this Association to adopt, that such specifications be submitted by the secretary to the members of the Association in a separate pamphlet, and that the committee's final report be brought up for consideration at the next convention, it being understood that the report will be included in the next Proceedings, if it is ready, before publication. Carried.

MR. BENZENBERG: In case such conference and report with reference to standard specifications cannot be had until after the proceedings are printed, it is understood that the same will be sent out in pamphlet form anyhow.

PRESIDENT SHERRERD: That may be, without objection, included as a part of the motion.

This being the last session of the convention, we will be glad to entertain any miscellaneous business at this time before we proceed with the Question Box.

Mr. Boardman: I wish to bring up the question of either reconsidering the action taken at yesterday's session with reference to the amendments proposed by the special committee on Constitution and By-Laws and favorably recommended by the Executive Committee, or by motion to instruct the Executive Committee to revise the action of the convention with regard to date and place of next annual meeting, if in the judgment of the Executive Committee such revision should be by them deemed necessary to the best interests of the Association. I will frankly state that my object in bringing up this matter is to place within the power of the Executive Committee the changing of the place selected for next annual meeting, because personally I do not believe it is the best place to go in the interests of the Association.

Mr. Keeler: I have no objection to an amendment to the Constitution being adopted which would place the power of revising date and place of annual meeting in the hands of the Executive Committee, but I believe the holding of conventions in more or less retired situations where there will be nothing to interfere with the deliberations of the Association is a proper policy and one which will eventually be adopted.

Mr. Benzenberg: I think that to revise or reconsider any action which was taken by ballot when a large number of the members were present, would be establishing a dangerous precedent, to which I am opposed.

Mr. Kimball: Although originally one of the strong advocates of Boston as the place for the next convention, I suggest that the better plan would be to take a postal card ballot and thus avoid any question of snap judgment, because the entire membership is interested both financially and otherwise in the choice of meeting point.

Mr. Boardman: I agree with the previous speaker in deprecating anything like snap judgment, and think that the Executive Committee should be given the power to ascertain by whatever method they may select the consensus of opinion of the members.

MR. BENZENBERG: I agree that this would be a very good provision, especially in case of sudden contingencies, such as fires or epidemics occurring in cities previously selected, and will give as an instance the case of an association which had made no such provision for a possible change, and an epidemic breaking out in the city selected, they were unable to go there, or to hold a meeting elsewhere that year.

PRESIDENT SHERRERD: I desire the stenographer to note that there are sixty-five members of the Association present, and to announce that I will entertain a motion, if there is no objection, to reconsider the vote by which those sections of the Constitution as submitted by the Executive Committee yesterday and not then adopted were referred back to the Executive Committee to be printed; and in the event of such reconsideration, the Chair will entertain a further motion that it is the sense of this meeting that the Executive Committee be sustained in submitting the question of a change in location for the next convention to a letter ballot.

MR. BOARDMAN: I offer such motion to reconsider. Motion seconded by Mr. Penney.

MR. O'SHAUGHNESSY: I was not present when the vote was taken on place for next meeting; had I been I should have voted for West Baden, in accordance with a promise previously made, but I have since heard considerable objection to going there. I think that it is the inherent right and duty of every legislative body to reconsider any action taken, provided that after circumstances prove the propriety of such reconsideration. If some members have gone home that should not embarrass the further deliberations of those of us who remain on deck. The attendance at this session is visibly larger than at some other sessions of the convention, although the attendance throughout the entire convention has been good, and the convention has been a business convention from start to finish.

After some further discussion, the Chair put the motion to reconsider, and the same carried by a vote of 28 to 5.

On motion of Mr. O'Shaughnessy, Section 1, Article 9 of the suggested new constitution submitted heretofore by the Executive Committee, was now adopted, the vote being unanimous.

Mr. Kimball: I move that the balance of the proposed amendments to the Constitution, as recommended by the Executive Committee, and now before the house, be referred to the Executive Committee, with instructions to have the same printed and distributed to all members before the next convention, action to be taken upon the same at said meeting, together with action upon such other amendments as may be otherwise submitted and properly referred to the Executive Committee at or before that time.

The motion was seconded, and by consent amended to include printing in the Proceedings, and as amended adopted by the unanimous vote.

The Question Box was then taken up and the questions that had been printed in the advance edition were first read and discussed, a number of the members present taking part in the discussion, after which other questions were asked and discussed.

President Sherrerd brought up the subject of thawing services by electricity, which led to a general discussion on the subject of thawing frozen services and mains both by electricity and other means.

Mr. Keeler: I would like to offer a resolution and suppose this is as opportune a time as any, as the chairman has stated that he will entertain miscellaneous business. The membership of this Association will recognize that it involves a large amount of labor to provide the entertainment, make all necessary arrangements, etc., for the holding of the various conventions of this Association. Having had some experience along that line, I am pleased to offer the following resolution:

Resolved, That the thanks of the American Water Works Association be, and they are hereby, extended to the local committee for the very complete arrangements made by them for the comfort and entertainment of the members and geusts in attendance upon the present convention; especially do we appreciate the great amount of labor and effort necessary to accomplish so much, in view of the great number of attractions in other directions due to the Exposition season.

I move the adoption of the foregoing. Carried unanimously.

PRESIDENT SHERRERD: I would make the announcement that the Executive Committee held a meeting this morning to determine the date of the next annual meeting, and have fixed upon the week beginning the 8th of May, 1905.

We will now be pleased to listen to the paper by Mr. Edward S. Cole, entitled "The Water Waste Investigation in New York."

Mr. Cole read his paper, after a few brief introductory remarks, and after it had been discussed by Mr. Bemis and others the President announced a paper not on the programme, "At What Rate Can Water Be Profitably Sold When Pumped Against a 300 Foot Head," by Mr. W. A. Patton of Cattletsburg, Ky.

MR. PATTON said that as it was late, he did not want to take up the time of the convention, and asked that his paper be read by title and referred to the Publication

Committee, and if approved by them printed in the Proceedings for discussion at some future convention.

President Sherrerd then announced a paper by Mr. Dow R. Gwinn, entitled "About Collection of Water Rates in Advance—also List of Cities Collecting Frontage Tax."

This paper was also, on account of the lateness of the hour, ordered referred to the Publication Committee, and if approved printed in the Proceedings.

The Secretary read a communication from Mr. Samuel C. Lancaster of Jackson, Tenn., which was accompanied by a sample well strainer and some small samples from other well strainers; all were badly coroded, and as it was evidently the result of electrolytic action, the letter and samples were referred to the Committee on Electrolysis.

President Sherrerd: The President at this time would like to express his appreciation and thanks for the courtesies extended by the local committee to the Association, and desires particularly to thank the members of the American Water Works Association assembled in convention at St. Louis for their faithful attendance on the sessions of the convention, despite the fact that the meeting is held in a city which is having the greatest fair the world has ever seen, and in which there are so many counter attractions. I thank you very much.

Secretary Diven called attention to the fact that some criticism had been passed upon the plan of sending out advance copies of papers in order to prepare members to properly discuss the same in convention, in reply to which Mr. Rosamond stated that he had heard some such criticism from one member with which, at the time he had been disposed to agree, but upon further reflection he felt that the plan of sending out an advance copy was a wise one, and he now thoroughly approved of the same.

Mr. Penney had feared that the sending out of advance copy might lead some to believe that the benefits of the meeting could be secured on paper in that way, but he was reminded by the Chair and others that the benefits of the meeting were derived as much from the awakening of thought that was stimulated in all members who participated in the discussions at the meetings as well as in the information imparted individually by means of the many opportunities afforded through the close association and social converse of those attending the convention in hotel lobbies and elsewhere while the convention was in progress. These benefits could never be secured in like proportion by those who remained away from the meetings, and President Sherrerd urged that it was the duty of every water works official to endeavor to interest members of public boards, water commissioners and trustees to accompany members to the conventions.

MR. PENNEY stated that he had endeavored to interest the members of the board of public service in his city and induce them to attend the meetings as an educational feature, but so far without success.

PRESIDENT SHERRERD hoped that he would keep after them until he finally succeeded.

PRESIDENT SHERRERD requested all members to return corrected transcript of their remarks as promptly as possible to the secretary, in order that speedy publication of the annual report might be secured.

No further business offering, on motion of Mr. Rosamond, the convention now adjourned sine die.

SOCIAL FEATURES.

As was to be expected, when Mr. Ben Adkins invited the Association to come to St. Louis, there was no lack of recreation; and if any further assurance of a good time and opportunity to relax after the serious work of the convention was needed, the following list of "Local Committees" would supply it:

Local Committees.

GENERAL LOCAL COMMITTEE.

Benj. C. Adkins, Chairman; W. D. Walsh, Secretary; B. H. Sanders, Treasurer; M. L. Holman, W. H. Henby, W. H. Reeves, S. B. Russell, W. E. Rolfe, Chas. Horner.

RECEPTION COMMITTEE.

Joseph P. Whyte, Chairman; James M. Franciscus, L. K. Hammer, S. B. Russell, John Morrin, Robert A. Aull, Hon. Rolla Wells, James G. McConkey, W. E. Rolfe, M. L. Holman, G. H. Robinson, Hiram Phillips, F. W. Valliant, James Y. Player, E. E. Wall, W. H. Henby, J. A. Laird, A. G. Holmes, Chas. Varrellman.

LADIES' RECEPTION COMMITTEE.

Mrs. Benj. C. Adkins, Mrs. W. E. Rolfe, Mrs. S. B. Russell, Mrs. Hiram Phillips, Mrs. J. Wallace Brennan, Mrs. Harry Fulks, Miss Cora Clifford, Mrs. W. D. Walsh, Mrs. W. H. Henby, Mrs. W. H. Reeves, Mrs. A. W. Lawnin, Mrs. Louis Hammer, Mrs. Chas. Horner, Miss Florence Clifford, Miss Louise Saunders, Mrs. M. L. Holman, Mrs. E. E. Wall, Mrs. P. J. Clifford, Mrs. J. A. Laird.

ENTERTAINMENT COMMITTEE.

Benj. C. Adkins, Chairman; F. J. Bradley, W. A. Holmes, Geo. C. R. Wagoner, R. L. Hedges, J. S. Hamlin, P. J. Clifford, Harry Fulks, E. J. Buckley, Harry Collins, Wm. H. Henger, W. D. Walsh, A. H. McAlpine, W. H. Reeves, A. W. Lawnin, Harry Wohlmacker, Ed. Dunn, T. C. Clifford, Fred Mueller, Thomas Carter, Robt. W. Colglaizer, J. Wallace Brennan, C. F. Francis, J. W. Strackbein, John Mills, Edward Hoberg, J. W. Means, Ramsey Skinner, Tom Dwyer, W. H. McCurdy, Fred Hirsh, Charles Horner, George H. Carr.

The program was varied, and contained all that one could desire or imagine. The Monday evening Reception, though held before the convention could really be said to have commenced, was well attended, and was a most enjoyable time.

Tuesday afternoon all were loaded on automobiles, and after an enjoyable ride through some of the beautiful residence streets of St. Louis and over the famous, and almost perfect, bitulithic paved Boulevard, were landed in the fair grounds and had a most delightful spin through the drives, giving an unequaled opportunity to get a general view of them.

Till eight o'clock we were left to spend the time as we choose, seeing the things that each most desired to see, and after dinner on the grounds—mostly in the beautiful Tyrolean Village, where the cooking and service were excellent—all assembled in the theater of the "Irish Village" and witnessed a charming vaudeville. There was a physician in the party and under his advice and leadership the ladies were cajoled into taking off their hats and giving a clear view of the stage, without danger of "Eye strain."

We were reminded the next—Wednesday afternoon—that the Louisiana Purchase Exposition was not the only entertainment that St. Louis had to offer, and were treated to a delightful sail on the "Father of Waters." The trip was made on the steamer "Corwin Spencer," a characteristic Mississippi river boat. And it is rumored that to make things more realistic and more forcibly remind them of the "Good old days on the river, befo' de wah," when planters bet their fortunes on boat races and other games of (*less*) chance, for the player, the genuine old time river card shark was there. But this is only rumor.

The return was made in time for a comfortable and leisurely dinner at the hotel; and the evening spent on the fair grounds. First, witnessing an exhibition by the famous Hale's fire fighters of Kansas City. While this was a most realistic and well given exhibition of fire fighting and other matters connected with a model fire department, it had to take second place to our Ben's ride around the arena at the opening of the performance.

The rest of the evening was spent on the "Pike," where entertainment of all kinds was to be found.

Thursday afternoon we took a special train to the Anheuser-Busch brewery, and after a tramp through the various departments of that mammoth and model establishment, and an opportunity to test the fact that it was really beer that they made, we started for the Chain of Rocks Water Works, and yes! we got there, but had our troubles on the way. First there were the many delays getting back through the city, where the railroads were already overcrowded with fair visitors. Once out of the city we sped along the river, a beautiful ride, making a short stop at the pumping station, which model, and, of course, well kept plant, was briefly inspected; then on towards the Chain of Rocks, till the Burlington Bridge stopped us. The bridge was too low for all of our cars to pass under, and it was necessary to go back to the pumping station to switch off the offending cars. But the party was unloaded, as there was a tempting green bank on which to pose for a photograph and a photographer on hand. We were finally posed, when instead of the camera Charley Campbell came forth and presented Ben Adkins with a diamond stud on behalf of the Association. That the presentation was properly and gracefully made and the acceptance acknowledged in the same spirit it is needless to say. The photograph was then taken by the light of "Ben's" diamond; and the train returning soon after we proceeded to the Chain of Rocks, where Mr. Adkin's novel method of clarifying and purifying the Mississippi river water was shown and explained. After which a hungry crowd boarded the train for the return trip and something to eat; for the trip had consumed much more time than was expected, and many had left the city with little or no lunch, expecting to return in time for dinner, and it was now past eight. Two sordid souls cut the pumping station for something to eat, and they were an exasperation to the rest of us who would not let a little thing like hunger interfere with the performance of a duty. And to add to our misery someone passed through cars with the familiar cry of "Last call for dinner in the dining car." It came near being his last call. But we finally reached our hotels and there were a lot of busy waiters for a while.

Friday afternoon tickets for the Union race track and St. Louis Browns vs. Boston, American League, ball game were distributed; the game was called at 3.30 P. M. and all took lunch before going. Those who did not care for racing or ball took the time to again visit the fair, and later most all were to be found there, to view the superb cascade by electric light, and for a stroll on the Pike and dinner among the Alps.

EXHIBITS.

Owing to the fact that the convention was held in an Exhibition City, and that many of the usual exhibitors had their display at the Fair, less attention than usual was paid to this feature.

There were some new exhibits, however. Mr. H. P. Martin of Owensboro, Ky., exhibited the "Yale Self Locking Stop Cock Box"; the Kellogg sleeve was shown for the first time at a convention. The Clark Meter Box and the Dresser Sleeves and Couplings were also shown for the first time.

The other exhibits were by the Lead Lined Iron Pipe Co., Central Foundry Co., Union, National and Hersey Meter Companies, Cole, Flad Pitometer, Hays Mfg. Co., Columbus Meter Seal Co., Pleuger and Henger, J. B. Campbell Brass Works, H. R. Worthington—water meters—and Rensselaer Mfg. Co.

OBITUARY

FRANK W. HOLLY,
Honorary Member.
Born Seneca Falls, February 6, 1851.
Died Lockport, N. Y., January 15, 1904.

CHARLES FRED ALLEN,
Active Member.
Treasurer Hyde Park, Mass., Water Co.
Accidentally killed February 20, 1904.

LESTER E. WOOD,
Active Member.
Director Green Island, N. Y., Water Co.
Born Saratoga County, N. Y., 1848.
Died Pelham Manor, N. Y., January 1, 1904.

A. W. SCOBLE,
Active Member.
Superintendent Water Works, Fort Worth, Texas.
Born New York City, 1836.
Died Forth Worth, Texas, April 14, 1904.

MEMBERS PRESENT

AT THE

TWENTY-FOURTH ANNUAL CONVENTION.

ACTIVE

Adkins, B. C.
Affleck, John A.
Ahearn, John T.
Alderman, C. L.
Alvord, John W.
Amsbary, F. C.
Anderson, J. F.
Baker, W. H.
Bancroft, P. T.
Barker, W. H.
Bauman, C. V.
Bassett, Geo. B.
Beardsley, Joe. C.
Bemis, Edwin W.
Bennett, Thomas H.
Benzenberg, G. H.
Binder, Fred C.
Boardman, A. E.
Boeh, Wm. H.
Bolger, F. E.
Bond, Joseph A.
Brotherton, C. F.
Brown, Calvin S.
Brown, D. A.
Brown, Lew O.
Burnett, Muscow
Cain, W. L.
Caird, James M.
Calhoun, H. L.
Carlson, J. A.
Caulfield, John
Charles, S. A.
Chatham, Jay
Chisham, J. M.
Clark, H. W.
Cobb, Chas. H.
Cole, Edwin S.
Cole, John A.
Connor, F. J.
Cook, F. S.
Cook, Thos. R.
Cuddeback, Allan W.
Davey, T. W.
Deffenbaugh, J. M.
Dill, Howard A.
Diven, J. M.
Dunbaugh, Geo. J.
Durlin, Willis B.
Eggers, Aug. F.
Elbert, Edwin
Ellis, Robert N.
Ellwood, O.
Engel, C. C.
Fairfield, F. M.
Felix, Geo. H.
Fellows, C. L.
Fitch, W. P.
Ford, Edwin H.
Frailey, E. T.
Gailey, S. A.
Gallagher, John F.
Gannon, Thomas W.
Glazier, W. L.
Glore, W. H.
Goodell, John M.
Gwinn, Dow R.
Hale, A. K.
Harbster, M.
Healy, G. B.
Heeger, Emil I.
Heim, John B.
Henderson, C. R.
Hibbeler, H. D.
Hill, William R.
Holly, Ira A., Honorary
Holman, M. L., Honorary
Holmes, Alba L.
Hopkins, James A.
Horner, C. M.
Houston, George
Jefferis, L. M.
Keeler, H. E.
Kellogg, Robert M.
Kelley, John C.
Kennedy, Geo. G.
Kimball, Frank C.
Knox, W. Frank
Knudson, A. A.
Landis, C. W.
Lautz, Henry.
Lefavor, Walter L.
Leisen, Theodore A.

Little, Beekman C.
Lord, Harry A.
Lyon, Henry L.
McAlpine, A. H.
McArthur, Arthur.
McDermot, L. C.
McGrath, R. H.
MacDonald, Emmett.
Manning, John W.
Manville, F. D.
Martin, H. P.
Mather, Edmund.
Maury, Dabney H.
May, Chas. A.
Myers, A. H.
Michie, J. C.
Miller, J. A.
Miller, Jos. Torrence
Milne, Alex.
Molis, William
Moore, John M.
Myers, Geo. M.
Neubling, Emil L.
Neville, Thomas J.
Nourse, H. O.
Obliger, Louis B.
O'Shaughnessy, Jerry
Patton, W. A.
Peene, Edward L.
Penney, C. L.
Prentice, Allen T.
Priddy, C. N.
Purdy, J. H.
Randolph, W. C. N., Jr.
Rapp, Wm. H.
Reed, Wilbur F.
Riley, Lee
Roebling, F. W.
Rolfe, W. E.
Rosamond, S. J.
Rowe, Chas. E.
Russell, S. Bent.
Ryder, Philip F.
Shepperd, F. W.
Sherrerd, Morris R.
Simpson, Lawrence
Skirm, Chas. A
Slocum, Chas. Egbert
Spalding, E. B.
Sprenkel, John F.
Sterling, J. C.
Strauss, N.
Smith, Anthony P.
Smith, H. L.
Smith, Owen T.
Talbott, Frank
Thomas, Robert J.
Tilden, J. A.
Todd, William
Travis, Isaac N.
Tucker, A. A.
Veach, William Allen
Warde, J. S.
Watkins, Thomas
Watts, Sylvester
Watts, W. H.
Way, J. F.
Whipple, G. C.
Whitney, Dr. Geo. F.
Wiles, C. W.
Wilkerson, J. H.
Williams, Howard L.
Wirt, R. D.
Wood, John H.
Woodruff, Timothy
Worrell, M. L.
Young, Chas. H.
Young, Ezra P.

ASSOCIATE MEMBERS

Present at the Twenty-fourth Annual Convention.

Arnold, V. E., Pittsburg Meter Co.
Bailey, Geo. H., Jr., National Meter Co.
Bancher, Geo. Y., National Meter Co.
Baldwin, Chas. H., National Meter Co.
Brown, H. F., Neptune Meter Co.
Brown, C. S., Neptune Meter Co.
Bradley, F. J., National Meter Co.
Caldwell, Geo. A. H. Mueller Mfg. Co.
Calkins, Willis N., National Meter Co.
Carr, Geo. H., H. R. Worthington.

Corbett, J. T., Jos. T. Ryerson & Son.
Corbett, M. A., The Columbus Meter Seal Mfg. Co.
Corse, A. P., Neptune Meter Co.
Davis, J. H., Pittsburg Meter Co.
Daniels, James, U. S. Cast Iron Pipe & Foundry Co
Darrow, W. R., J. B. Campbell Brass Works.
Davis, Edward S., Detroit Chemical Co.
Dean, Mark, Central Foundry Co.
Dwyer, Thomas E., Lead Lined Iron Pipe Co.
Faulks, T. D., Neptune Meter Co.
Ford, W. B., H. Mueller Mfg. Co.
Folger, H. C., Secy., Thomas Meter Co.
Francis, C. S., National Meter Co.
Goodhue, A. E., U. S. Cast Iron Pipe & Foundry Co
Glauber, Jos. H., Glauber Brass Mfg. Co.
Hawkes, A. W., General Chemical Co.
Hanley, P. M., Hersey Mfg. Co.
Hall, Frank E., Union Water Meter Co.
Harrison, Samuel, H. R. Worthington.
Hammond, C. H., E. H. Kellogg & Co.
Henger, H. W., Pleuger & Henger Mfg. Co.
Heinrich, W. C., H. Mueller Mfg. Co.
Hersey, Walter A., Hersey Mfg. Co.
Higley, S. D., Thomson Meter Co.
Holmes, Al. G., Pittsburg Meter Co.
Holley, E. B., Neptune Meter Co.
Holmes, W. A., Pittsburg Meter Co.
Horton, Horace E., Chicago Bridge & Iron Works.
Humphreys, E. C., U. S. Cast Iron, Pipe & Fdy. Co.
Irving, George, National Meter Co.
Jackson, Powell, Jackson Filter Mfg. Co.
Kelley, John C., Jr., National Meter Co.
Knefler, Dan'l W., The Cook Well Co.
Koetter, Edw. P., U. S. Cast Iron Pipe & Fdry Co.
Jones, Octavus, Rensselaer Mfg. Co.
Leary, T. F., H. Mueller Mfg. Co.
Leopold, F. B., N. Y. Continental Jewell Filteration Co.
Leck, D. B., National Meter Co.
McGarry, John T., American Valve & Meter Co.
McCarthy, Vincent, R. D. Wood & Co.
Means, J. N., Rensselaer Mfg. Co.
Mueller, Adolph, H. Mueller Mfg. Co.
Mull, E. F., Hersey Mfg. Co.
Mueller, Fred B., H. Mueller Mfg. Co.
Mueller, O. B., H. Mueller Mfg. Co.
Nagel, T. J., Hays Mfg. Co.
O'Brien, D. F., Anthony P. Smith Mfg. Co.
O'Day, W. J., Jas. B. Clow & Sons.
Otis, A. S., Union Water Meter Co.
Perkins, M. G., Neptune Meter Co.
Pray, A. J., Pittsburg Meter Co.
Putnam, H. J., Thomson Meter Co.
Reynolds, Irving H., The William Todd Co.

Regar, Joseph, Glauber Brass Mfg. Co.
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PAPERS PRESENTED

AT THE

TWENTY-FOURTH ANNUAL CONVENTION

OF THE

AMERICAN WATER WORKS ASSOCIATION

AND DISCUSSIONS ON THEM.

MODIFICATIONS OF THE PLAN OF THE NEW CROTON DAM.

By William R. Hill.

The responsibility of the engineer in charge of constructing dams and reservoirs, is but vaguely appreciated by the public. In view of the many disastrous failures that have occurred, due to faulty plans and poor construction, it is made imperative for the engineer to exercise his best powers to insure proper and substantial structures. There is, perhaps, no other field of engineering that develops in the course of construction so many new conditions and unexpected obstacles, and when the engineer finds it necessary to make radical changes in the plans, even though involving heavy expenditures and subjecting himself to severe criticism, it is his bounden duty to make these changes.

The writer had the honor of being Chief Engineer of the Aqueduct Commission of the City of New York, from January 1st, 1900, to October 14th, 1903. During his incumbency the new Croton Dam was under construction.

The purpose of this paper is to explain, as briefly as possible, the original plan of this structure and the imperative necessity of its modification, and to answer a general demand made upon the writer that would seem to indicate a very widespread interest in these notable changes. Had the work continued under the original plan it might have resulted not only in the failure of the structure itself but have been the cause of immeasurable loss to this great city of its supply of water in addition to an appalling destruction of life and property.

The boroughs of Manhattan and Bronx, of an estimated population of 2,200,000 are dependent almost entirely upon the Croton River for their supply of water; in fact, they have no other supply, except the comparatively small quantity (20,000,000 gallons per day) from the Bronx and Byram Rivers, small as compared with 290,000,000 gallons, the present daily consumption of these two boroughs.

The natural flow of Croton River in dry seasons was judged insufficient to supply the city as early as 1843, now more than 60 years ago, so Croton Lake of a capacity of two billion gallons, was then created by building the old Croton Dam. Since then, from time to time, six other reservoirs, having an aggregate capacity of 40,000,000,000 gallons, have been built on the principal tributaries of the river, above the lake, for the purpose of collecting water in wet seasons, to be discharged into the lake as required for use. The city has no auxiliary supply, and no lakes or rivers that could be used as such in case of an emergency, hence an accident to a reservoir might result in so great a loss of water as to cause a water famine, truly styled one of the world's greatest disasters.

The new Croton dam is located about thirty-seven miles from the Central Park reservoirs, it is on the Croton River, about two and one-half miles below the old Croton dam. Its purpose is to enlarge Croton Lake, increasing its capacity from two to thirty-two billion gallons and its length from five and one-half to nineteen and three-quarter miles. The old dam will be sumberged, as the flow line will be raised thirty-six feet.

The clearing of this great basin for the reservoir, twenty miles in length, was in itself an extraordinary undertaking, embracing the clearing of all timber, the removal of three villages, numberless buildings, farm houses and cemeteries and the abandonment and reconstruction of railroad tracks, telegraph and telephone lines, highways and bridges.

The work of constructing the new Croton dam commenced October 1st, 1892. It calls for a very large quantity of masonry; in fact, there will be no less than

800,000 cubic yards. In this connection it may be of interest to note that it will be the largest block of masonry in the world, excepting the Egyptian pyramids.

There are three distinct features of the dam, the spillway at the north end; the main stone dam crossing the valley and the embankment at the south end. The spillway wall is built on the side of the valley, curving up stream from the stone dam; it is 1,000 feet long, 10 feet high at the end and 150 feet high at its junction with the dam. It is rubble masonry, faced on the water side with cut stone in regular courses and the lower side is in steps of large blocks of stone. A channel for the overflow is excavated in the rock back of the wall leading down to the river below the dam. The main stone dam, according to the original plan, was to be 600 feet long, extending from the spillway to the foot of the slope at the south side of the valley, thence an embankment and core wall 568 feet long was to continue to the end, making a structure 2,168 feet long.

The main stone dam is rubble masonry, faced on both sides, above the surface of the ground, with cut stone in regular courses. It is 297 feet high from the deepest point of the foundation, which is 131 feet below the bed of the river. Its greatest width at the base is 206 feet and the width at the top is 20 feet. At the junction with the core wall according to the original plan it had a height of 230 feet. For the purpose of reaching a point where the core wall would have a lesser height, the Aqueduct Commissioners on Sept. 16th, 1896, on the recommendation of the former Chief Engineer, authorized him to extend the main stone dam 110 feet, in substitution of the embankment and core wall, but even at the point thus reached the core wall would have a height of 200 feet. This extension materially increased the cost of the structure.

The embankment was to be 30 feet wide at the top, with sides sloping in the ratio of two horiozntal to one vertical.

The lower portion of the inner slope to a height of 16 feet below the crest of the spillway, to be paved with stone, 18 inches thick, laid dry, upon 12 inches of broken stone, and on the upper part of the slope to a height 12 feet above the crest of the spillway, the paving stone was to be two feet thick, upon 18 inches of broken stone. The core wall in the centre of the embankment was to be four feet higher than the crest of the spillway, six feet wide at the top and increasing to 18 feet at a depth of 136 feet, then same width to the base. The core wall was to be 200 feet high at the junction with the stone dam and 90 feet high at a gate house that is built in the embankment, 290 feet from the stone dam. The high end of the core wall had been built in a wide pit, that was a necessary excavation for the end of the stone dam, which was 164 feet wide at the base, while the core wall was but 18 feet at its base. The slope of this pit extended southerly along the line of the wall for a distance of 150 feet, thus the core wall at its highest end was not built in a narrow trench below the surface of the ground, as is usual in ordinary cases.

The bed rock on the north side of the valley is gniess and the structure is founded upon it for a length of 1,200 feet. The character of the rock then changes abruptly from gniess to lime stone and this extends southerly beyond the end of the structure. Although the contract drawings, upon which the contract was based, indicated "hard rock" at a depth of 75 feet below the bed of the river, yet it was found necessary to excavate the foundation pit to a depth of 131 feet before finding a firm foundation of hard rock. The character of the stone removed varied greatly; in places it was compact, then diversified by masses of stone broken up by open, eroded and mud-filled seams, and in places there were belts of disintegrated lime stone. During the progress of the excavation water flowed freely through the seams and several open caves were found in the rock. In consequence of this great additional depth, it was also necessary to greatly increase the width of the base of the dam. Thus again the cost was materially increased because of the additional quantity of excavation and masonry.

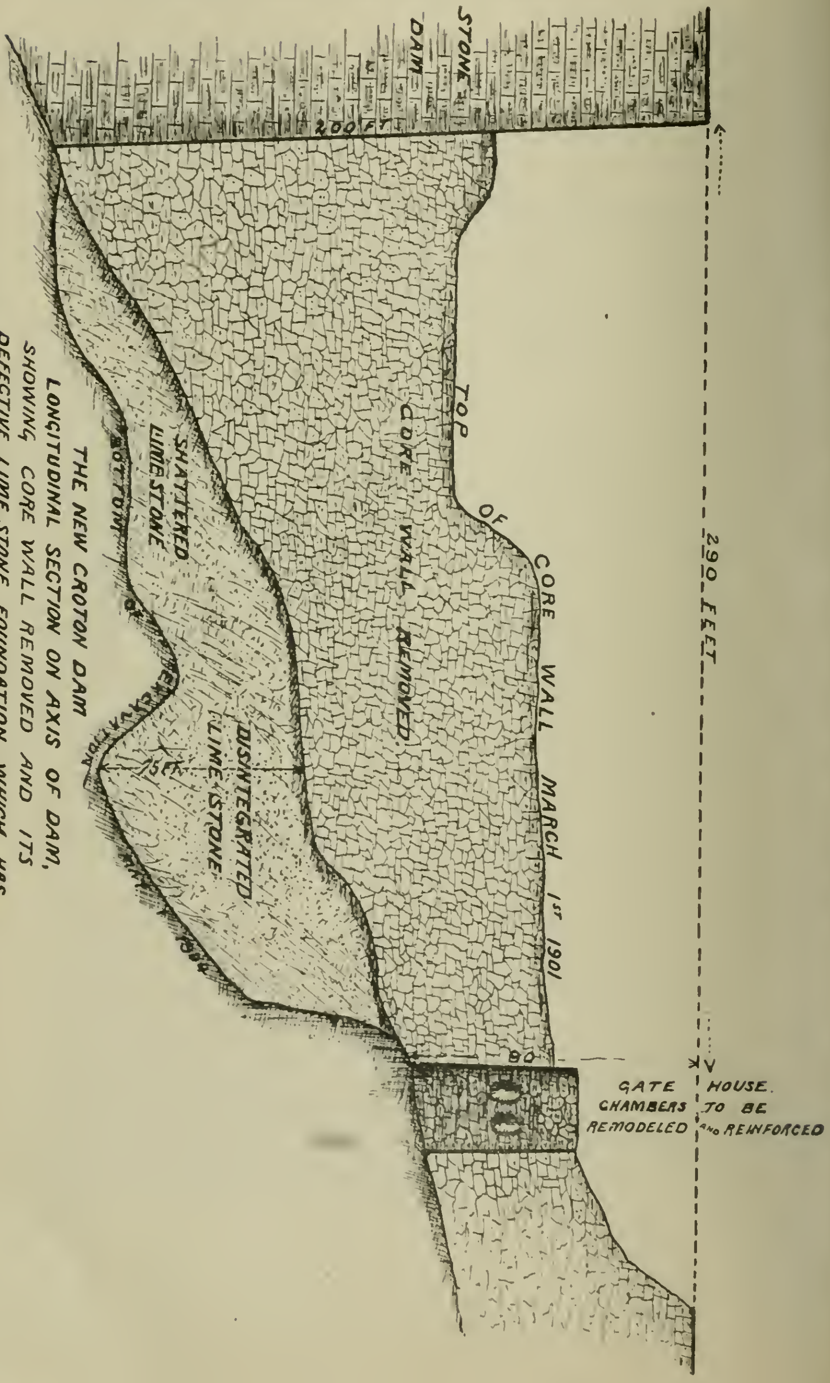
Before the writer assumed the responsibility of this work, the foundation of the stone dam had been completed to the surface of the ground and the core wall had been completed, excepting the stretch between the stone dam and the gate house, which lacked about 60 feet of its height.

In the spring of 1901, this core wall cracked in five places within a length of 100 feet. This caused the writer to believe that some serious disturbance had taken place, as in his opinion the cracks were too close together to be caused by contraction. After close study of the conditions, there was no conclusion to be arrived at except that there was a fundamental weakness here, and, therefore, it would be unsafe to proceed with the work. This close study brought to view objectionable features of the plans of the embankment and core wall, the most conspicuous of which were three. First the excessive height, narrow base and unstable foundation of the embankment; second, the great height of the core wall, and, third, the double means afforded the water to reach the core wall.

To take up the first, the embankment: It was to be 150 feet high, and only 650 feet thick at the base. This section, would be not only about 40 per cent. higher than any heretofore built, but in comparison with other high embankments its base was narrow for its height. As an example, the Amawalk dam, which forms one of the upper Croton reservoirs, while only about half the height, 85 feet, yet has a base even wider than that of this embankment of unprecedented height. And further, this embankment was hazardous because of the unstable nature of its foundation. It was founded over a great refilled pit, which was 360 feet wide at the top, 170 feet at the base and 70 feet deep; this pit was a necessary excavation for the foundation of the end of the stone dam, which was 164 feet wide at the base as before stated. It would be impossible to refill this pit as compactly as original ground, hence the safety of the reservoir was dependent not only on an embankment of a problematic section, but this problematic section, rested upon an unstaple foundation.

The second of the objections, the core wall of this embankment was 200 feet high and with no lateral protection or support from original ground whatsoever, as the artificially placed earth on each side of the wall had the height of the wall itself, 200 feet. Considering the height of the wall, and this in artificially placed earth, it could be but an experimental structure, inasmuch as it woud be about twice the height of any heretofore built.

The third objection, the double means afforded the water to reach the core wall, this is another serious objection, as the water by starting at the end of the embankment in the reservoir and following between the face of the stone dam and the embankment would inevitably reach the core wall. It would be impossible to puddle or otherwise compact the embankment against the dam to prevent this, as settlement would surely follow in any embankment of this great height. This objectionable feature here exists because of the combination of a stone dam and an embankment, while it could not exist in either a continuous stone dam or, on the other hand, a continuous embankment and core wall. As to the second channel by which the water could reach the wall there is also little doubt, for it would be afforded freer access through the refilled material of the great pit, than it would have in ordinary cases, where the wall below the original surface of the ground is in a narrow trench and protected by



THE NEW CROTON DAM
LONGITUDINAL SECTION ON AXIS OF DAM, SHOWING CORE WALL REMOVED AND ITS DEFECTIVE LIME STONE FOUNDATION, WHICH HAS BEEN EXCAVATED FOR THE EXTENSION OF THE DAM.

original soil. It would be useless to consider any proposition to increase the width of the embankment, because the means afforded the water to reach the core wall along the face of the dam would always remain ; this is a most dangerous feature, as the core wall would not have sufficient weight or strength to resist the pressure of the water that would come against it.

A fourth objection might here be stated, namely, the permeable and light character of the earth of which the embankment was made, but even with the best of material, an embankment so constructed would be insecure.

Thus it will be seen that the safety of this reservoir was dependent not only upon an embankment of a problematic section, resting upon an unstable foundation, but also upon a core wall of phenomenal height, unprotected and unsupported by original soil and attended with the greatest of all possible risks, that is the means afforded water to reach the center of the embankment against the core wall.

Such a structure can not be regarded as anything but an experiment. It is abnormal and unprecedented in all its dangerous features. The engineer might apply in vain to science for aid in computing the efficiency of such a structure; he could get no light, for he could find not even the slightest guaranty of safety in a structure so built.

The failure of this embankment might not only create a devastating flood in the valley below, but also cause a current above, of such irresistible velocity, as would destroy the earthen part of the old Croton dam, thus at once cutting off the supply of water to the city until the old dam could be repaired and in addition postponing indefinitely the time when the city could have the additional supply of water which the enlarged reservoir was to furnish.

Thus, the writer, was thoroughly convinced that a change in the plan of the structure at this point was necessary. Thereupon he recommended to the Aqueduct Commissioners that this entire section of the embankment and core wall to the gatehouse be removed and the stone dam extended in its place. But while maintaining that the conditions allowed of no other conclusion, he recommended that a committee of three engineers be appointed to pass upon a question of so vital and widespread importance.

The Commissioners after personal investigation agreed in this and appointed a committee of expert engineers consisting of Messrs. J. J. R. Croes, Past President of the American Society of Civil Engineers; Edwin F. Smith, Chief Engineer of the Schuylkill Navigation Company and Elnathan Sweet, former Engineer of the State of New York. The committee after making an investigation reported unanimously recommending this extension of the stone dam to the gatehouse.

The general public will no doubt feel that great weight has been added to these conclusions by the concurrence of the eminent Engineers Prof. William H. Burr, occupying the Chair of Engineering of Columbia University, and Mr. Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment of the City of New York; both of whom had been asked by Mayor Low to investigate and report thereon. On April 16, 1902, the Aqueduct Commissioners resolved to remove the embankment and core wall and to continue the main stone dam to the gatehouse.

The estimated cost to complete the embankment and core wall under the original plan was $145,233.00, while the preliminary estimate of the cost to remove the embankment and core wall and extend the main stone dam is $635,700. The difference $490,467 being due to this modification, yet there will be a further increase because of the condition of the natural foundation of the core wall, as hereinafter described. In considering this estimate one should not loose sight of the fact that there has been a loss sustained of about $80,000, the cost of that part of the core wall that had to be thus abandoned.

In March, 1903, the core wall having been removed, it became apparent that the embankment and core wall would have been undermined and destroyed if completed under the original plan. The core wall was found to be resting upon lime stone that in places was completely disintegrated, to the form of loose sand and other portions in the process of disintegrating, were more or less hard, the softer part being in such a condition that it could be easily crushed by the hand to the form of sand and would absorb water as freely as would a sponge. The hardest of this stone was full of eroded, open and mud-filled seams, the existence of mud being evidence that these seams had acted as passageways for water. Under date of April 1, 1903, Prof. Burr, who had concurred in the condemnation of the wall, reported to Mayor Low as to the foundation as follows: "It is most fortunate that the core wall has been removed so as to disclose the actual situation and thus remove what would have been a source of gravest danger to the completed embankment structure as originally planned."

Prof. J. E. Kemp, of Columbia University and Prof. J. J. Stevenson, of New York University, both geologists, were retained to investigate the locality affected. They reported that the conditions were deserving of very serious considerations and that in certain locations the material was found to be so soft that in their own words it "runs with water like sand." Under their advice this loose and disintegrated rock has been removed to the depth of 75 feet below the base of the core wall, for it is only at this great depth that a suitable foundation for extending the dam has been found. The removal of this soft rock and the replacing it with masonry has again materially increased the cost of the structure. The work of building this masonry is now in progress.

Another important change of plan is that of the gatehouse, above referred to. This gatehouse is located in the embankment outside of the core wall. It is well up on the slope of the valley, its base being about 100 feet higher than the bed of the river. The substructure of this gatehouse is described as follows: It has four water chambers, 74 feet deep and about 12 feet square. Two on the southerly side of the structure are to control the flow of the water in the old Croton aqueduct which passes through this gatehouse. The other two on the northerly side, are to control the flow of water direct from the reservoir to the old aqueduct below the dam. These two chambers are connected with the reservoir by three brick inlets, 10 feet in diameter. And they are to hold water to a depth of 54 feet, yet the outer walls (which are enclosed in an artificial embankment)have a uniform thickness, from the base to top of but eight feet, while safe construction demands that they should be about four times that thickness at the base.

These walls which had been built to a height of fifty feet, would not have sufficient strength to resist the water pressure that would come against them, and their destruction might result in a great losss of water from the reservoir and the demolition of the embankment, by the rush of water in falling a height of 150 feet to reach the valley below. On Dec. 18, 1902, on the writer's recommendation the Aqueduct Commissioners approved a plan providing for the reinforcement of these walls.

The preliminary estimate of the cost to construct the dam under the original plan was $4,150,573. This will be increased to about $6,400,000. The great increase in the cost of the work is due principally to the four above described additions and modifications namely: the extra depth excavated under the main stone dam, the first extension of 110 feet of the main stone dam, the extension of the main stone dam necessitating the removal of the embankment and core wall and lastly the additional excavation necessary for the foundation of the last extension. Some idea of what these changes have necessitated may be gained from the consideration of but two items, that of the amount of earth excavation which will be trebled and that of the amount of masonry which will be increased from 550,000 to about 800,000 cubic yards. The value of the work done to March 1, 1904 is $5,363,000.

This most important of all structures to this great city, upon which its welfare would be almost wholly dependent, had to be mantled with all possible safeguards against its destruction. Thus the writer being brought face to face with the one paramount necessity that of the safety of this structure, was left no alternative but to modify the plan.

DISCUSSION.

Mr. Maury: The society is to be congratulated upon hearing at first hands, from Mr. Hill, so clear and concise a statement of the matters relating to the Croton dam. I am sure that we feel very grateful to him for what he has given us.

Mr. Hill suggested that Mr. Cook, the engineer of the Aqueduct Commission, could give some light on the question.

Mr. Cook (Assistant Engineer, Aqueduct Commission). At a Methodist meeting members are very glad to hear from a young convert. As I have just joined the Association, I may be classed as a convert, and you may be desirous of hearing from me. However, I am reluctant in responding.

As to the filling back of the core, I will say the filling was placed in behind the core wall of selected material, sand and what might be classed as disintegrated hardpan. It was generally put in layers, watered, then rammed or rolled. It would, at least, be interesting for you to know that while the excavation to remove the core wall was being made, showing you that Mr. Hill's proposition to remove the core wall was well grounded, one day, while on the work, I noticed down in the pit water breaking through from the material yet to be excavated, welling up in three or more jets of, perhaps, from one to four inches in diameter, and, in time, drowned out the pumps. This water seemingly came from the river above, which may have had a head of only about 40 feet. Thus you are able to see, should the reservoir be filled to a depth of 150 feet, what might have been the pressure through the disintegrated rock underneath the core wall, spoken of in Mr. Hill's paper.

Mr. Maury: Do I understand that this water was water that had passed underneath the core wall?

Mr. Cook: No; this was natural water that came from the valley above the dam and filled into the 45 foot trench or excavation; and eventually water would have found its way beneath the core wall, through the loose material, to a much larger extent due to the added pressure (150 feet) of a full reservoir.

Mr. Bemis: I think there is a very important lesson in this paper for us all that has a tremendous importance to our cities in realizing the need of expert engineering and in their being willing to pay enough to get it and following the advice given when it is secured. Of course, Mr. Hill has not said so, but we will recognize that there was an awful blunder committed by some previous administration of the water works at New York, or some, or all, of this extra expense would not have been necessary. I venture to say that that is true as to a great many other water works in this country. We have had similar experiences in Cleveland, and I believe that it would be very profitable to us all to recount some of these, and have a little experience meeting, if we had time. One of the greatest weaknesses, I think, in American water works management has been the unwillingness to appreciate the importance of high class engineering, and to pay enough for it, and then to follow the advice given.

Private companies make blunders, too. I do not think they are as sharply criticised for their blunders as are public officers, but they make them just the same. We had an experience in Cleveland which illustrates that, when the Pennsylvania Railroad undertook to build a freight house along Lake Erie, and one fine morning it began to slide into the lake. Ultimately the whole building tumbled down. This disaster interfered with the operation of trains for several days on the Lake Shore and Pennsylvania on account of the obstructed condition of the main track, besides putting them to large expense otherwise, all in consequence of an engineering blunder in regard to the foundation of the building. If such a blunder had been made in constructing our pumping station located not so very far away along the same lake, I suppose it would have overturned the administration; but we heard very little talk about the matter in the case of the Pennsylvania Railroad, it being a private corporation. Yet they must have felt very sore over their blunder, which cost them many thousands of dollars to remedy. I believe, though, that our water departments have made blunders equally serious, in proportion to the size of their plant, as was made in this Croton reservoir; but fortunately, perhaps, for the administration in charge at the time, the mistakes were not recognized until after the administration responsible for them was out of office.

I take it, therefore, that this should bring home to us the truth that not only do the dangers of the spoils system confront the management of public supplies like water works, but an equally great danger faces them in the failure to have sufficiently good engineering assistance. We are developing in this country of late a new profession—that of the expert engineer who is called in to solve special problems; and I think that when designs for the installation of new machinery are being considered, or ways sought for the checking of waste water—outside, perhaps, of meters—such as the development of a system of measuring the waste in big mains, or the question of electrolysis, or the finding of new sources of water supplies, or the purification of old ones, that there is not a department in this country sufficiently well managed to work out such problems without being very much benefited by expert aid from outside. We need to educate our city councils and boards of public works into the wisdom of paying liberally for such expert engineering assistance on those lines; and in this view I think it hardly possible to over-estimate the importance of the lesson to be drawn from this paper of Mr. Hill's. (Applause.)

Mr. Heeger: We had an experience in Evansville, Indiana, in connection with the water works plant constructed there about three years ago, and of which we were extremely proud at the time. An engineering mistake, however, caused a serious settling and cave; in consequence of which the entire water supply of the city was shut off for some little time, till help from other cities and new material ordered at great expense gave us a temporary supply, while the work was being reconstructed.

This experience of ours illustrates very forcibly the necessity of the greatest care in the selection of a suitable location and the proper construction of a water works intake or other supply. Our mistake caused, in addition to the great inconvenience and danger, an expense of over $30,000 for a temporary supply.

During this trouble the insurance representatives of the state threatened to raise the insurance rates, but by borrowing several fire engines and with those we had on hand, and with our auxiliary pumping station, we managed to pull through our troubles until we had our temporary intake completed. We had more fires during our trouble than in the six months previous; but they were all controlled by the good work of our fire department, and the mud and sand furnished by our water works at the time—and for fighting fires mud and sand are a success.

Mr. Rosamond: There are engineers and engineers. In the southern part of Arkansas I was called to a new plant on some special work. I knew very little of what was going on there, except that they were building a water works plant. I rendered the services for which I was called upon, and after completing that work was asked to go and look at a site where they proposed to build a dam to impound water for three months in the year; they not having sufficient flow from this spring to tide them through the fall. When they requested me to go there, I asked that their local engineer go with me. We got out there and I examined the proposed site for the dam. He had his plans in his pocket, a pencil sketch. The dam was to be 190 feet at the top, 30 feet high, and his plans called for 12.5 feet thickness at bottom and 2 feet at the top. He never would have made that fill, I do not think. Yet they were going to build that dam to impound water for a spring and water shed of several square miles, a mountain side. The flow from that spring passed through the center of the town, and would wipe it out if the dam should ever give way. I think they will, however, build the dam about 25 feet at its base.

If we could get such papers as Mr. Hill's before municipal and other owners of water works, we would accomplish what Mr. Hill is trying to do, that is, educate the people along this line. I think this question of the construction of dams for impounding water is the most important that could come before us. Some of the worst disasters in this country have been due to the bursting of dams. I think Mr. Hill, in a paper presented by him at one time, gave us the data with respect to loss of life and property from this cause in the past several years. I would like it if such a paper as that might be distributed all over the country, but, unfortunately, it is impossible for us to undertake it.

Mr. Sherrerd: I think that New York City is to be congratulated on having Mr. Hill come into this position as chief engineer at the time he did. From an engineering standpoint, this question of the construction of the Croton dam has raised a great deal of controversy.

Mr. Hill has so explicitly explained what he found when he took hold of this work and made so radicaal a change, that I think that it is only just to the memory of his predecessor, who is dead, that something be said in his behalf. (Applause.) It carries with it a lesson to us all. I am not going to justify or attempt to justify what was laid out to be done on the Croton work under the administration of Mr. Hill's predecessor except so far as that work was laid out by the responsible head himself when he was capable of doing it. The Chief Engineer of the Aqueduct Commission was a very sick man at the time that he was finally allowed to resign from the active service of the Commission. I know personally that he desired to resign at least a year before he did. His reputation was world wide, and I think that that fact, in a manner, justified his subordinates in going on with his plans. And the point that I want to bring out at this time is not a justification of what was proposed to be done, but that every chief engineer should look out for his own personal reputation, and when he cannot get on the ground himself, then he had better resign. (Applause.)

Mr. Boardman: The remarks of Professor Bemis in regard to the services of experts, and the necessity of educating councils and public officials as to their value, is rather amusingly illustrated by an incident that recently came to my own knowledge. A small town in South Carolina desired to build a water works, the people having voted bonds for that purpose. They wrote to the Engineering News requesting to be put in touch with an expert engineer who could devise plans and tell them how to build the works, and give them the approximate cost. The Engineering News wrote to an intimate friend of mine who happened to be in a Southern town near this point, and asked him to correspond, having previously given his name to the mayor, who asked for the information. The engineer therefore wrote to the mayor saying that he would be very glad to serve them in that capacity, and that, as he was so near the scene, he would only charge them fifty dollars a day and his actual traveling expenses to go down, look over the ground and make them a sketch of what was needed, and a preliminary estimate; that it would not take a very long time to do that, and then if they wished to employ him further he could make terms in the regular way. A reply came back very promptly from the mayor, saying that he had received the letter, but thought there had been a typographical error in the sum mentioned. He presumed that what was intended was five dollars a day, and if so he would be very glad to have my friend come over immediately. He has not gone.

EXPERIENCE WITH GROWTHS IN WATER MAINS.

By Owen T. Smith.
Secretary and Superintendent Water Co., Freeport, Ill.

Prof. E. G. Smith, of Beloit, stated in his paper last year at Detroit, that I would present a paper giving my experience at Freeport with growths in water mains and with that, its cause and cure.

The main reason for offering this short paper is that in some way it may help some other superintendent to overcome without so much trouble, similar difficulties, and that life may be made a little easier to him who has the health of the community in his hands as well as its protection from the fire fiend.

Prof. Smith has given us in his admirable paper a description of the organism, its habitat and characteristics and it will therefore not be necessary for me to go into that in this paper, so I will confine myself to the part showing how we got rid of the trouble.

In the fall of 1895, the water supply of our city, Freeport, Ill., suddenly acquired a bad taste and odor, which we could not account for, in the ordinary way, the supply being from wells in the drift along the river bottom.

The mains were flushed and the suction pipe cleaned by a large flue brush, made to order, and all that we thought could be done, was done, to get rid of the trouble.

We could not locate the seat of the trouble, for some time, until finally, we gathered a sample of water, with a yellowish brown matter floating in it, and sent it to the State University at Champaign, for analysis. The chemist reported the water not bad, but that the floating matter was known as crenothrix kuhniana or well thread, which had given trouble in some parts of the United States and a good many places on the continent of Europe.

Learning this, we procured all the data we could and began a systematic study of the growth and the means of getting rid of it. We found that the growth depended upon the iron in solution, in the water. We also found that it required about .30 parts per million of the iron, in order to feed the growth. If this amount could be materially reduced, then it was thought that the growth would die and slough off and finally be eliminated from the system.

We flushed the mains and the system thoroughly, very often during the season and kept the growth down, as much as we could, in that way, but the service pipes and small mains began to fill up, and in some cases, shut off the flow of water entirely. We kept studying the matter carefully, and finally came to the conclusion that the only adequate means of eliminating this growth was the construction of a filter plant for the removal of the iron and carbonic acid gas, the latter being quite large in amount.

We arranged with the New York Continental Jewel Filtration Co., to erect a small experimental plant at the works, to ascertain just what could be done by filtration.

In the various analyses of the raw water which were made, during these experiments, the amount of iron varied greatly, from as much as nineteen parts per million, in the outskirts of the system, while at the pumping station and in the city, upon some of the large mains, the amount was much lower. Following is a table showing several amounts obtained from samples taken on several successive days, from different parts of the system and the result obtained by filtration in the experimental plant.

At Pumping Station:

Amount of iron determined as metallic iron:

1.38 parts per million.
.70 " " "
.60 " " "
.65 " " "
.65 " " "

Average, .796 parts per million.

On mains and at dead ends:

1.63 parts per million.
5.00 " " "
1.25 " " "
1.25 " " "
1.25 " " "
1.25 " " "
.75 " " "
.8 " " "
5.00 " " "
.4 " " "
2.00 " " "
.5 " " "
2.5 " " "
19.2 " " "
.55 " " "
1.00 " " "
.65 " " "
.55 " " "
2.00 " " "
1.4 " " "
1.12 " " "
5.5 " " "

The larger amounts were in water from the dead ends.

The average amount of free carbonic acid was 21.4 parts per million in the raw water.

Amount of Iron in Filtered Water:

.06 parts per million.
.06 " " "
.04 " " "
.045 " " "
.03 " " "
.03 " " "

Average, .045.

All the carbonic acid was removed in the filtered water.

The amount left in the water after filtration, being well within what several chemists considered to be the limit, below which, the crenothrix could not live, we concluded to contract for and build a filter plant. We asked bids from several different concerns and received bids, varying from $11,000 to $15,000, for a two-million-gallon filter plant.

We, after a thorough investigation, determined to enter into contract with the New York Continental Jewel Filtration Co., they, to design the plant and plan of the buildings. The Water Co. to build all the foundations and the building and do all the piping and furnish the low service pump and connect with the filter plant at the wall of the pump house. The Filter Co., to erect the filter plant, complete, within the walls of the building and after completion, make a test run of thirty days.

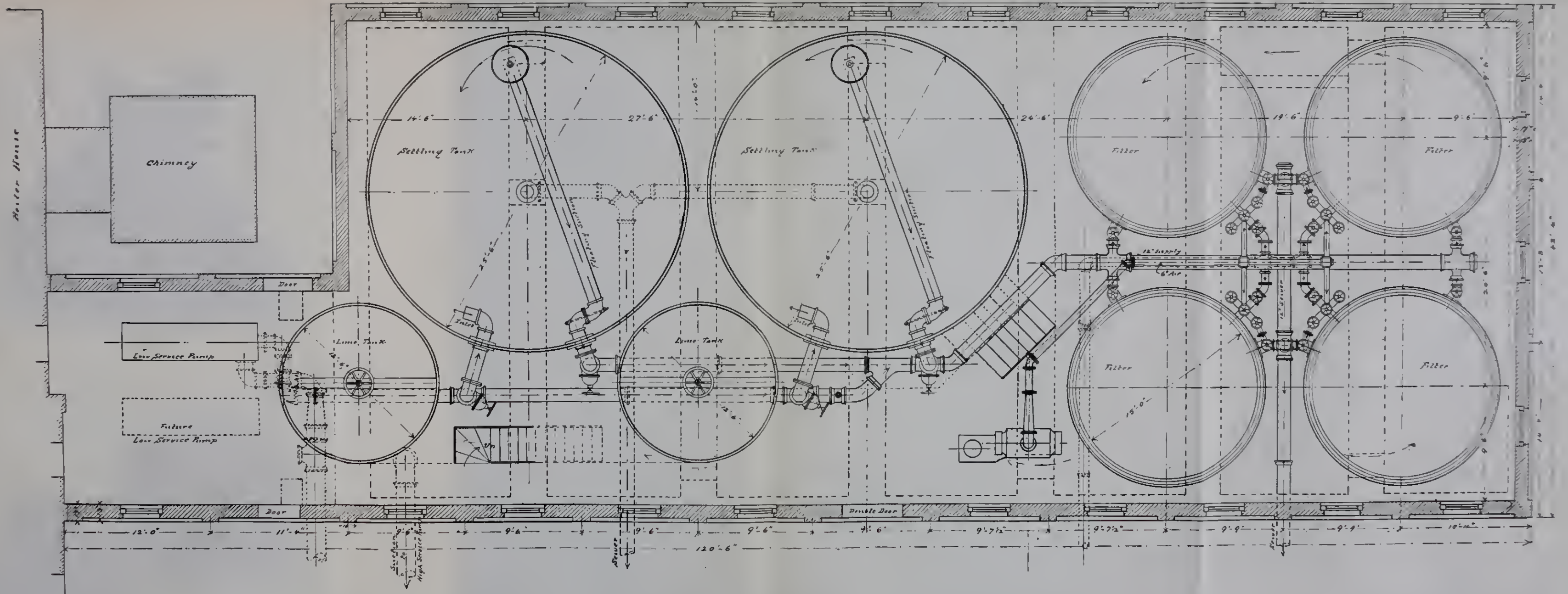
This was contemplated during the season of 1902, but on account of the high cost of all building material, especially cement, iron pipe and lumber, it was determined to postpone building, until the next season. Early in the spring of 1903, the construction was started, the foundation walls and reservoir underneath being made entirely of cement concrete, the building being of substantial brick construction, and the filtering and settling tanks being constructed of 3-inch red cypress. The so-called air wash was used for washing, instead of rakes and the entire plant was constructed by the Filter Co., in a thorough and very substantial manner, complete in every detail. The filter was started on the 13th of October 1903, and began a thirty days' test run.

Prof. E. G. Smith, of Beloit, was retained by the Water Co., to make its analyses, while Mr. Robert E. Milligan, of the Filter Co., was in charge of the plant for them. The plant was started and ran for a few days before Mr. Milligan arrived, running the water through the sand, without any coagulant. whatever. This showed quite a remarkable reduction in the iron in the water, but it also showed that there was no removal of the carbonic acid gas.

When Mr. Milligan arrived, we began the use of plain lime water, as a coagulant. using from two to four grains of lime per gallon. The result was, that the iron was reduced to an average of about .04 parts per million, while all the carbonic acid gas was removed and the water softened 13 to 15 per cent.

This average has been continuously maintained up to date. We have found that with in the six months since the plant started, that the growth has been absolutely stopped and the old growth, while giving us much trouble by sloughing off and making the water roily and bad, yet by heavy flushing, this trouble has been very largely removed and we find now, where we have cut the mains that while there is a little of the old growth still remaining, yet a large percentage has been removed by the flushing.

In the discussion of paper, read by Prof. E. G. Smith before the convention in Detroit. the question was asked him, if the growth had been found in meters. We have some photographs of a meter which had been on a service where the supply was almost altogether stopped, which shows the condition of a large numer of our services, before the Filter Plant was installed.



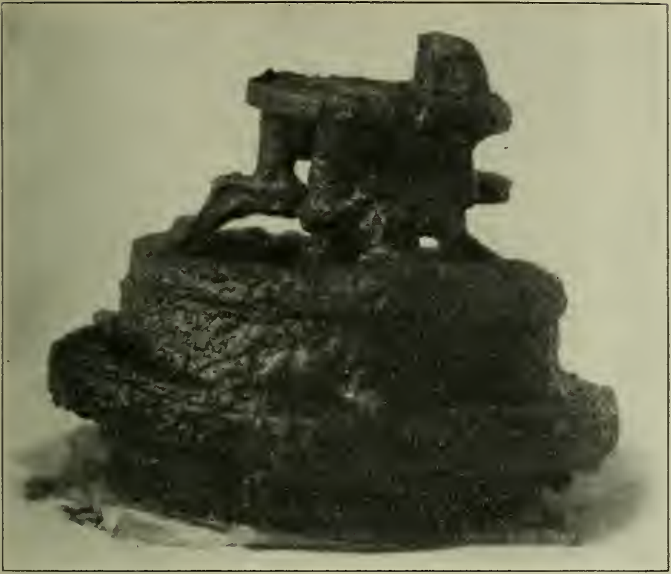
JEWELL GRAVITY FILTER PLANT

DESIGNED FOR

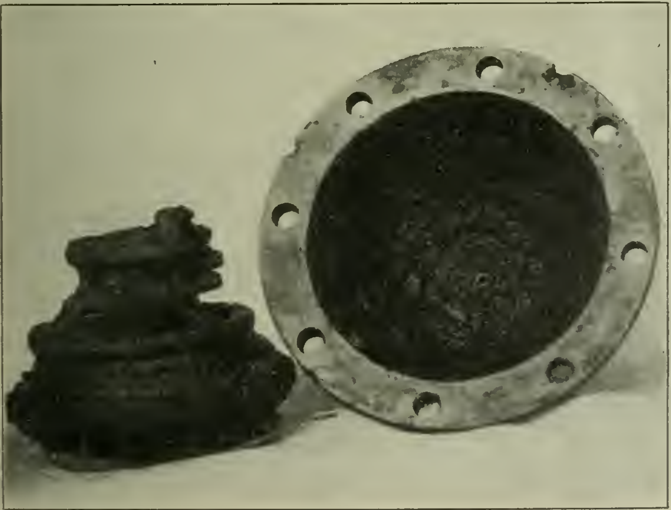
FREEPORT WATER CO., FREEPORT, ILL.

BY THE NEW YORK CONTINENTAL JEWELL FILTRATION CO.

Proceedings American Water Works Association, 1904



ACCUMULATION OF CRENOTHRIX ON WORKING PARTS OF ⅝-IN. METER.



SHOWING ACCUMULATION ON INSIDE OF METER.

FILTER PLANT, FREEPORT, ILL.

FILTER PLANT, FREEPORT, ILL.

MR. CHARLES: My experience along this line may be of some benefit to others. We have in Lexington, Ky., impounding reservoirs which are peculiarly susceptible to the growth of algæ. We have found that the amount of algæ depends far more upon the temperature of the water than upon other conditions. As warm weather approaches, whenever the water comes anywhere near the temperature of 70°, algæ accumulate in our reservoirs, especially in the shallow spots. Our remedy is filtration and aeration, in combination with a thorough system of flushing, which we continue five days in the week, alternating on the different lines by means of valves by which we cut off one main supply and force the current all through certain lines down to the lowest point in the system, where it is washed out. We prefer to wash out the mains at the bottom rather than through a hydrant, as the hydrant opening is about three feet above the main, and the discharge is not as effective. We use sulphate of alumina as a coagulant. We inject it in such a way that we can put in the millionth part of a grain per gallon, or the ten-millionth. We put it in regularly. Where it is used in this way a smaller quantity suffices. We have in connection with our duplex pump a smaller pump which, working in unison with the duplex pump, allows of the injection of a solution of any desired strength. We use about one-third of a grain per gallon.

I have noticed in the papers recently a notice of the use of sulphate of copper, and I wrote to Mr. George Moore of Washington, as it was stated they had experimented with it there. He sent me a pamphlet in which it is stated that this sulphate of copper is more destructive to algæ than anything else and not injurious otherwise. Our chemical advisor tells us that a sulphate of copper solution is somewhat dangerous and requires special care in using; therefore, while we are experimenting with sulphate of copper, we are doing it on an outside pond and not our own reservoir. We have not yet arrived at any solution of the question as to whether it is of any benefit or not, but our impressions, so far, are against it. We have been very successful in removing algæ; indeed, we have no trouble at all with our flushing and filtrating system combined. It takes all the algæ out of the pipes. Of course, if allowed to remain, they will germinate, decompose and impart a bad smell to the water. The remedy is not to let them stay in the pipes, but flush your pipes thoroughly. Do not make your storage reservoir for filtered water too large. The object is not to hold water in storage any longer than necessary and to use it as soon after filtration as possible. (Applause.)

Mr. Patton: In the paper just read the writer did not state in what form the iron was found in the water. I suppose, of course, it is one of the salts of iron. The Illinois Steel Company is now strongly recommending to the City of St. Louis the use of sulphate of iron as a coagulant, and I think it is important to know in what form the iron is found in this water which has been referred to.

Mr. Smith: They call it metallic iron, or oxide of iron in solution.

Mr. Whipple: The paper which has been read was very interesting to me, because Crenothrix is an old friend of mine. I have found this organism occurring in a great many water pipes and sometimes in driven wells, for a good many years. I think that the author has solved the problem in the right way, and that the principle is one which can be extended still further, namely, that the proper way to do to get rid of the organisms occurring in water pipes is to cut off their food supply and starve them out. There are a great many organisms found in water pipes other than crenothrix, which have given even more trouble. We had an experience in Brooklyn not many years ago that will be long remembered. At the time I took charge of the laboratory of the Water Supply Department one of the reservoirs was filled with a growth of Asterionelli which was giving a bad odor to the water. One of the first things we tried to do was to see if we could not improve the quality of the water by temporarily isolating this reservoir from the system. There was no regular by-pass to the reservoir, but we found that by making certain changes in the gates it would be possible to change the direction of the flow so that the water would not pass through the reservoir, but would go directly into the system, and that change was made. Instead of having the beautiful result that was anticipated, the next morning two or three hundred complaints were registered at the office that no water could be drawn from the service taps; and, in fact, there were several hundred places in the city where the service pipes were completely stopped up. During the forenoon there were reports that two boilers had collapsed where 2″ pipes had been plugged up with growths of pipe moss, as the engineers termed it, which had been growing in the city pipes. This pipe moss was an animal form known as Paludicella. It occurs in the pipes in braching interlaced filaments which would take the direction of the flow of the current, and when the direction of the flow was changed these little strings of organisms were broken off, and the network passed down the pipes and lodged in the service taps.

Now, the remedy for all these things is to prevent the organisms from getting their food supply. These pipe organisms, or the most of them that I have described, live on the minute plants and animals (microscopic organisms) found in the water. If we can get rid of these latter in the reservoir, we shall get rid of trouble from such growths in the water pipes as I have described.

I think that the question of incrustation of water pipes is very largely a biological one. There are some instances where tuberculation occurs by itself alone; there are other cases where it is complicated with the presence of iron and crenothrix in the water, and there are many more cases where it is complicated by the growth of this pipe moss and a variety of other organisms which I will not attempt to name. In the latter case the action that takes place is something like this: These growths of organisms occur on the pipe walls, and between them and the walls there is a layer of air from which the oxygen is, at times, temporarily exhausted and where carbonic acid may be at times very large in amount, this condition being brought about by the organisms. When these organisms are broken off there is a little spot on the pipe where the iron may be exposed to the action of the carbonic acid. Then, again, when the iron becomes oxidized it may be deposited around those little spots in a crystalline form. Hematite, you will remember, crystallizes in a botryoidal form. So the tubercles are really crystalline deposits of iron, mixed up, of course, with a great deal of extraneous matter.

There are several ways of dealing with growths of organisms in pipes. One way, and perhaps the usual way, is to let them grow and do nothing. The result is a foul condition of the pipes, a decreased carrying capacity and often dirty water. Another way is to clean the pipes, using one of the several devices which have been recently brought to our attention. The best way, however, is to do what the author has done, namely, to remove their cause of growth, to take away their natural food supply and starve them out. This need not always involve filtration, but it is an argument for filtered water which is too often lost sight of.

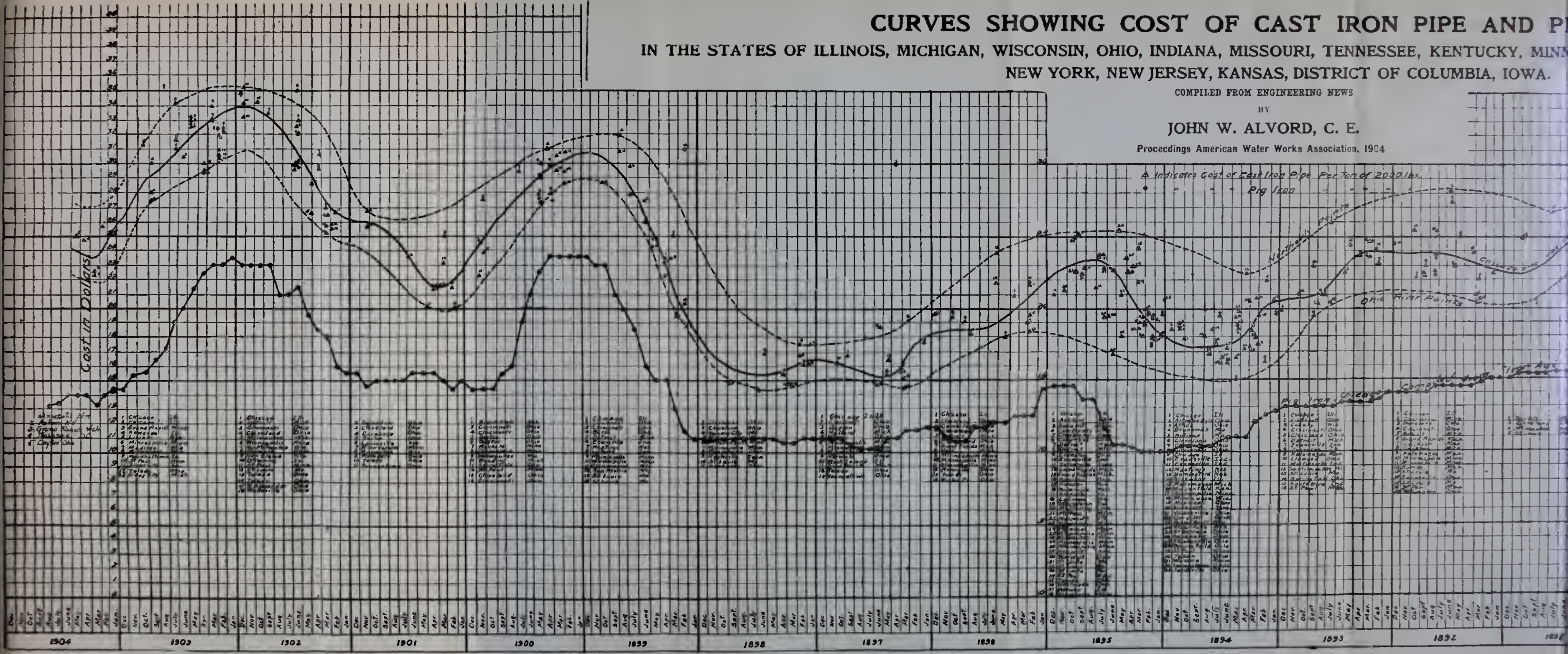
Mr. Maury: I should like to ask Mr. Whipple one question. You all know that the Government has recently issued some quite interesting pamphlets in regard to the use of copper sulphate under certain conditions, for the destruction of animal and vegetable growths in reservoirs. Nothing is said in the pamphlet with regard to the effect of this solution, when introduced into a reservoir, on the growth of crenothrix. I should like to ask Mr. Whipple if he is in a position to give us any information on that point.

Mr. Whipple: I do not think that I can give you the information that you request. It seems to me that in regard to this sulphate of copper method of treatment we can best follow the injunction of Captain Sigsbee of the U. S. Battleship Maine: "Now is the time when judgment should be suspended." (Laughter.)

CURVES SHOWING COST OF CAST IRON PIPE AND P

IN THE STATES OF ILLINOIS, MICHIGAN, WISCONSIN, OHIO, INDIANA, MISSOURI, TENNESSEE, KENTUCKY, MINN
NEW YORK, NEW JERSEY, KANSAS, DISTRICT OF COLUMBIA, IOWA.

COMPILED FROM ENGINEERING NEWS
BY
JOHN W. ALVORD, C. E.
Proceedings American Water Works Association, 1904



ST OF CAST IRON PIPE AND PIG IRON

NDIANA, MISSOURI, TENNESSEE, KENTUCKY, MINNESOTA, NEBRASKA, MASSACHUSETTS, ERSEY, KANSAS, DISTRICT OF COLUMBIA, IOWA.

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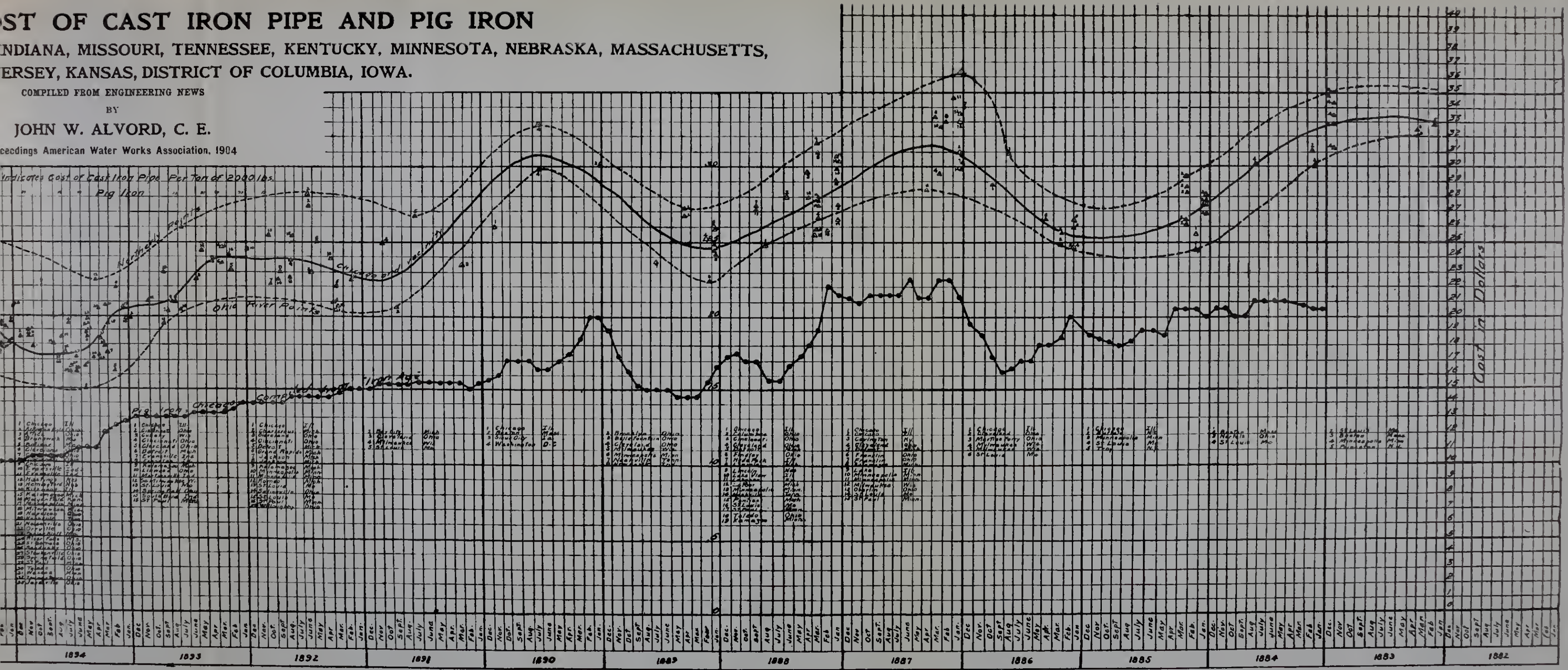


THE COST OF CAST IRON PIPE.

JOHN W. ALVORD, C. E.

CHICAGO.

No subject gives the water works man more anxiety from season to season than to properly place his orders for cast iron pipe, so as to take advantage of the market so far as possible. And it very often happens that expensive extensions become necessary when the pipe market is at its top notch, and, on the other hand, it is difficult to finance improvements when pipe is low. The importance of determining the amount and character of fluctuations in the pipe market is one that has been fully realized, but so far as the writer is aware, there is nothing on record which will give a clear idea of the amount and character of these fluctuations.

Having had some occasion to obtain information as to the average cost of pipe during the last ten years, the annexed diagram has been prepared showing the actual contracts which have been made since 1883 for cast iron pipe in the states of the Central West centering about Chicago.

No effort has been made to reduce these prices to a common freight rate from the factory, but they have been plotted just as they have been taken from the Engineering News and other sources, the lower dotted lines showing the average prices at Ohio River points and the upper line at the more remote points in the Northwest.

This diagram cannot fail to be of interest to all those who are watching current prices, and who may be able to reason from the past as to what the probabilities are for future contracts.

Mr. Alvord: I desire to call your attention to the fact that this paper is a record-breaker for brevity. There is nothing to the paper but the diagram, which you have all probably seen in the advance copies of proceedings. I think that the subject matter will, however, appeal to you all as being of some interest. I will forbear to read the paper which will appear in the proceedings later on.

I might say that in preparing this diagram I had in mind the running down of one or two traditions that have largely existed in my own mind; one of these was that there was an annual fluctuation in the pipe market distinct from the fluctuation due to the general state of finances in the country and the laws of supply and demand. I think, perhaps, it has been commonly thought that the pipe industry early in the winter faced the contingency of having to carry over their stock until the late spring when the demand begins to come in, and, therefore, reduce the price in proportion to the amount of interest on the stock they would have to carry; and that a little later in the spring when the demand becomes active, prices naturally rise until late in the fall, when everybody is rushing to get their work in in season and they then reach their maximum. This is one of the myths that I wanted to unearth. I could not find any evidence of it year by year in the prices which I have tabulated.

There are a number of other interesting points which I think each one of you will appreciate without my elucidating them. The marked depreciation of 1894 to 1898, and the repeated fluctuations up and down since that time have undoubtedly caused a great deal of distress of mind to a number of you in making your estimates and then being blamed because your final results came out materially different. I would be glad if any thought is brought out on the subject by the diagram. I might further say that it would have been interesting if I had the time to do so to have dotted on the diagram the cost of pig iron, which would undoubtedly have followed very closely the curves as given. My time did not permit of my doing it.

MR. GWINN: I was very much interested in the diagram furnished by Mr. Alvord. I understand that the difference between the cost of pig iron and the cost of cast iron pipe has increased in the last few years. If not too much trouble I would like to have Mr. Alvord show the cost of pig iron on his diagram when it is published in our Proceedings.

MR. ALVORD: I think that can be very readily done, and I will be glad to do so.

SOME RECENT DEVELOPMENTS IN WELLS AND PUMPS.

By Dabney H. Maury, Consulting Engineer,
Peoria, Ill.

Fortunately, the time is now past when, except amongst the ignorant and unprogressive, any hole in the ground is considered a well, and any device for lifting water, a suitable pump. And the absolute necessity for so co-ordinating the design of the well and of the pump that each may be best adapted for operation in connection with the other, and both with due regard for all the surrounding conditions, is now becoming more widely recognized.

So far as wells are concerned, this paper will discuss more particularly those which draw from water-bearing sands or gravel.

These wells may either be open wells or driven wells. An open well is generally understood to be a well of a diameter so large that a man may enter it, and which has its shoe or bottom edge in the water-bearing stratum, and takes water from under the shoe.

Driven wells are generally from two to fifteen inches in diameter and, if they draw water from sand or gravel, they are usually provided with some sort of strainer or well point, designed to hold back the sand and gravel while admitting the water. These strainers act in one of two ways:

1. Their openings may be so fine as to exclude the finest sand to be found in the water-bearing stratum. Or,

2. The openings may be made considerably larger than the finer particles of the water-bearing stratum, but somewhat smaller than the coarser particles. This construction contemplates the drawing in of the finer particles through the openings, by any one of a number of methods, and the removal of these particles by repeated pump-

ing, so as to ultimately form, outside of the metal strainer proper, a greatly enlarged strainer area, composed of the mass of the coarser gravel adjacent to the strainer.

It is hardly necessary to say that the latter method of construction is the rational one, where there is any considerable proportion of even fairly coarse sand or gravel in the stratum. Where there are no coarse particles, good modern practice would still employ the strainer with large openings, as the necessary amount of coarser gravel may be dumped in, a little at a time, at the top of the well, rammed down, and out at the bottom, the well being pulled back as far as necessary, and then re-driven through this gravel. When, by the repetition of this process of dumping in, ramming, pulling back, and re-driving, enough coarse gravel has been introduced to form a sufficiently large gravel strainer, the gravel remaining inside the pipe is finally removed with a sand bucket, the strainer is set, and the well is pulled back again to expose the strainer. Water is then pumped until the finer particles of sand and gravel cease to flow in, and the well is ready for service.

A well having a strainer composed of gravel, and of an area so large that the velocity of water flowing through its interstices shall not be great enough to draw in the finer particles of sand in the stratum, cannot clog up; and its useful life is limited only by the time required for the entire destruction of the metal shell of the strainer which holds the gravel back.

The use of any form of strainer which depends upon wire gauze or thin perforated metal to hold back the fine particles of sand, is, for many reasons, undesirable. Even while the strainer is new, the friction through the fine openings in the strainer, and through the very small voids in the fine material which packs itself closely against its outer surface, greatly reduces the yield of the well; and as corrosion clogs the openings the yield becomes still less. As this corrosion increases, the wire gauze or thin metal is destroyed in places, and the sand then flows in through the broken spots, and fills the strainer.

Of the countless forms of strainers which are designed to hold back all the fine particles in the soil, the best that the writer has found is that brass strainer, familiar to every water works man, in which the slots are cut and beveled from the inside; but this also will, in time, corrode; and its capacity, even when new, can never equal that of a wrought iron pipe, with punched or slotted openings from one-half inch to one inch in width, and surrounded by a gravel strainer many times its area.

While many examples might be cited in support of the foregoing statements, the experience with certain wells designed by the writer some years ago will serve as fairly good illustrations.

In 1895, in order to increase the water supply of the Peoria Water Company, an open well, eleven feet inside diameter, was sunk by the pump-and-sink method, at a point 3,340 feet north of the existing main well. In this well were installed two pumping units each consisting of a centrifugal pump having a vertical shaft, on the upper end of which a Pelton water wheel was set. A cast iron pipe conveys water at 120 lbs. per square inch from the force main of the main steam pumping plant, and this water is used to operate the Pelton wheel which drives the centrifugal pump. The water lifted by the centrifugal pump is discharged into a 24 inch tile pipe leading back to the main well, and into this tile pipe the water used to run the motor is, after it has done its work, also discharged by gravity, and flows back to the main well with the pump water. A full description of this hydraulic transmission system was published in Engineering News of January 13, 1898.

It was the original intention to sink the eleven foot well all the way to bed rock, seal its bottom, so as to make a water tight pump pit, and then drive out horizontally through the wall of the well a sufficient number of push wells, equipped with strainers, to admit to the suction pipes of the pumps as much water as the ground would readily yield. There was little or no gravel found in the water-bearing stratum, which was almost entirely composed of sand of medium coarseness.

The well was sunk without difficulty, at an average rate of over two feet per day of ten hours, until within about eight feet of hard pan, at which point the rate of inflow of the water through the narrowing annular space between the well shoe and the bed rock became so great that the sand was dragged in as fast as it could be removed; and it was found impossible, with the appliances at hand, to sink the well more than one foot further, which brought it to within about seven feet of bed rock.

An attempt to push down a steel cylinder 10 feet in diameter, inside the well, had to be abandoned after much time and labor had been expended, with a gain of only one foot more in depth. Four 6 inch wells were then driven to bed rock in the bottom of the well, and four more 6 inch wells were pushed out through openings in the wall of the well twelve feet above bed rock to an average distance of about 8 feet. All these wells were fitted with Cook strainers and were connected to the suction pipes of the centrifugal pumps. The whole plant has been in very successful operation, whenever the low water conditions required its use, ever since; but the capacity of the well was somewhat disappointing, and tests made from time to time show that the head required to overcome the friction of flow of the water through the sand to the strainers, and through the strainers themselves, is, as our present better knowledge of the state of the art would lead us to expect. very great.

In 1899 it was found necessary to improve the main well of the Peoria Water Company in order to increase its capacity and to shorten the suction lift of the main steam pumping engines.

The suction pipes of the main engines were shortened, and a steel tank was built around them, so that they should, at times of low water, draw from the tank instead of from the main well.

Four wells were sunk to bed rock inside the main well and close to its wall. Each well was a steel cylinder, elliptical in cross section, with diameters of four and five feet, and was sunk by the pneumatic process through 19 feet of gravel.

Into each well, after it was sunk, was lowered a steel trussed frame, carrying at its lower end a centrifugal pump with its suction and discharge pipes, and at its upper end a Pelton water wheel connected to the extension of the vertical pump shaft.

The motors are so connected as to be driven by water under pressure from the force main of the steam pumping engines, and the motor water, having done its work, flows into the tank, to be pumped over again by the main engines. The centrifugal pumps deliver their water into the tank through openings in its side. The result of all these changes is that the capacity of the well is increased at low water from 40 to 50 per cent., while the suction lift of the main pumps is now not greater than about 12 feet. This plant was described in detail in an article in Engineering News of April 26, 1900. The article did not, however, relate the later experiences with the strainers on the four steel caissons.

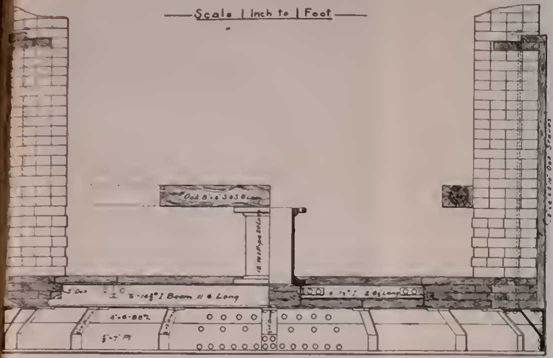
The lower section of each caisson was, for a length of 4 feet, punched with ¾ inch holes, 70 holes to the square foot. Inside the shell of the caisson, and covering the inner surface of the punched portion, was a sheet of perforated copper, the holes in which were about 3-64th inches in diameter. This sheet was fastened to the outer shell by cap screws, copper wires being inserted between

— DETAILS OF WELL SHOE BEFORE SINKING —

— FIG 1 —

— Partial Vertical Section On Line K-K —

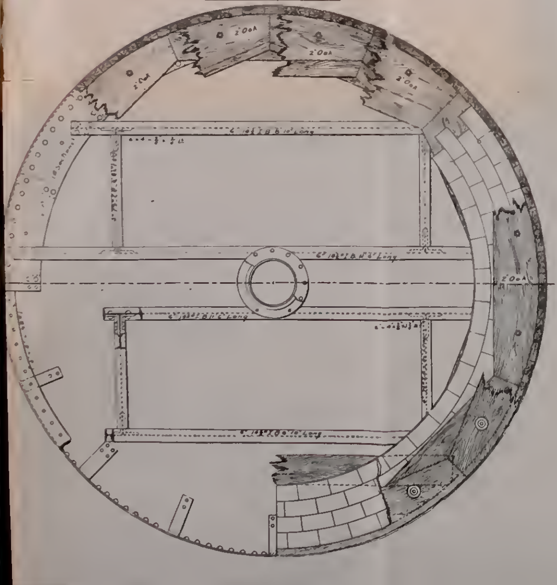
— Scale 1 Inch to 1 Foot —



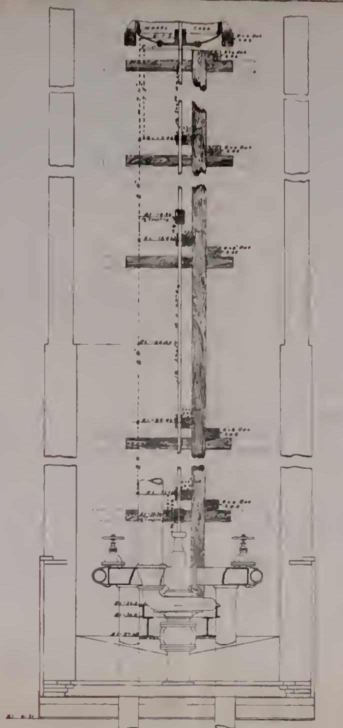
— FIG 2 —

— Partial Horizontal Section —

— Scale 1 Inch to 1 Foot —



— ARRANGEMENT OF MOTOR, PUMP AND SHAFTING —



— FIG. 3 —

— Vertical Section on Line K-K —

— Scale ½ Inch to 1 Foot —

— DABNEY H. MAURY, —

— CONSULTING ENGINEER, —

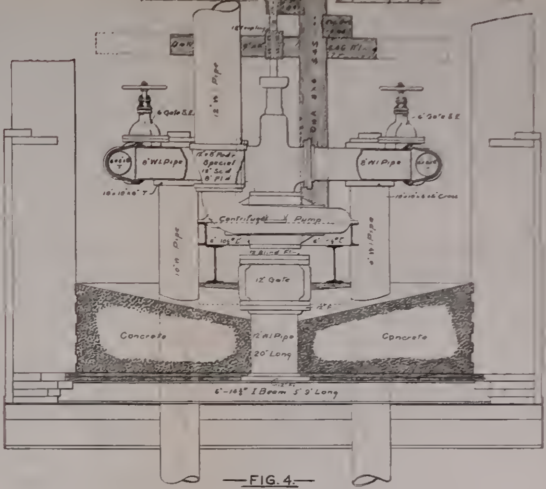
— PEORIA, ILL., JAN., 1901 —

PLATE I

— DETAILS OF WELL SHOE AFTER SINKING —

— Showing Location of Driven Wells, —

— Pump and Suction and Discharge Pipes —



— FIG. 4. —

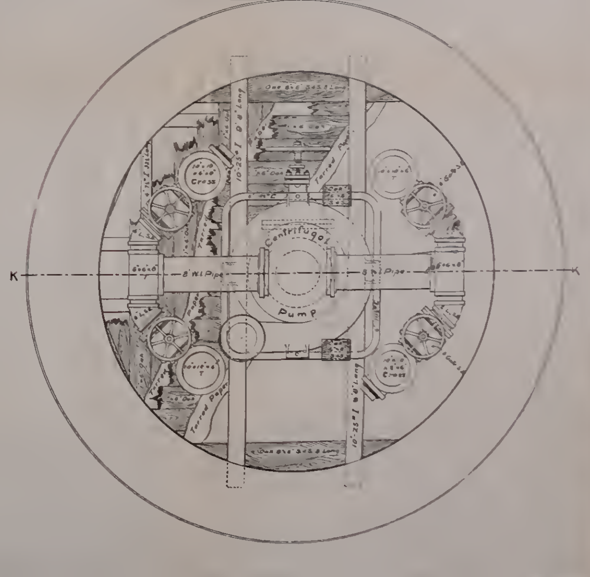
— Partial Vertical Section On Line K-K —

— Scale 1 Inch to 1 Foot —

— FIG. 5. —

— Partial Horizontal Section. —

— Scale 1 Inch to 1 Foot —



Proceedings American Water Works Association, 1904.

the copper sheet and the outer shell in order to give the necessary clearance. After the plant had been running for some little time, it was found that a head of about fifteen feet was required in order to force one and a quarter million gallons per day through each of the strainers. In order to see what was the matter the writer went down to the bottom of one of the caissons while the pump was running, inspected the strainer, and found that most of the small holes in it were completely closed. He then drove a drift pin through the copper sheet and through a three-quarter inch hole in the outer steel plate, and worked the pin around in the gravel outside. As soon as the pin was withdrawn a three-quarter inch stream of water spurted out with sufficient force to go entirely across the caisson. The water was at first discolored; but in a few seconds ran perfectly clear. More holes were then punched through the copper plate with the drift pin, and in a few minutes the water rose inside the caisson so fast that the writer had to climb out hastily.

All the copper sheets were ordered removed, and as each sheet was stripped off, the drift pin was used to work in the finer material in the gravel around the caisson. The next test made on one of the caissons showed that with a head of about eight feet, water was forced through its improved strainer at the rate of more than four million gallons per twenty-four hours, and without dragging in sand.

The writer was not long afterwards called upon to design a well for a water-bearing stratum of considerable depth, the normal water level being close to the surface, and the stratum being composed almost entirely of sand, with little or no gravel.

Realizing that it would be impossible to sink an open well by the pump-and-sink method to any very great depth, it was decided to sink the open well only as far as might prove, as the work progressed, economically practicable; then sink four 10 inch driven wells in the bottom, seal the bottom, and draw from the driven wells. The driven wells were to be equipped with strainers composed of 9 inch wrought iron pipes, 20 feet long, with slots about three-quarter inch wide, and surrounded by a mass of gravel dumped in from the top, as previously explained. This construction, which is shown on Plate I, Figs. 1, 2, 3, 4 and 5, would have resulted in giving a dry pump-pit in which the pump would be set far below the normal water level—probably 35 feet—and the capacity of the four 10 inch wells with properly prepared strainers would probably have been not less than from three to five million gallons.

By the time the plans for this well were completed, however, the writer had devised another design for a well for the same conditions, which embodied so many advantages that it was preferred to the one just described.

This design, Plate II, Figs. 1 to 20, contemplated a well of smaller diameter, but very much larger strainer area. The well can be sunk either by the pneumatic or pump-and-sink process; the strainer is of gravel, and the construction is such that the strainer is carried down with the well, being closed against water and air pressure during the sinking, and afterwards uncovered so as to permit the inflow of water. The well shown on Plate II was designed to be sunk 63.25 feet in sand. It may be considered as divided into three sections, the strainer section; the intermediate section, built of thin steel, to be lined, after sinking, with masonry; and the upper section, which is of masonry, and which also includes a small circular well house above ground, to house the motor.

The strainer section is nine feet outside diameter and 19.25 feet long. It consists of two cylinders, with an annular space, to be filled with gravel, between them. The two cylinders are joined at the top by a flat plate in six segments, each having a circular manhole to give access to the annular gravel strainer; and at the bottom, by a frustrum of cone, terminating in a cylindrical cutting edge. The two cylinders are also securely braced throughout their whole length.

The inner cylinder is of heavy steel, punched with a large number of one inch holes, arranged in rectangular groups, each group being closed, during sinking, by a steel plate with air-tight gasket.

The outer cylinder is a skeleton built up of horizontal circular angles and channels connected by vertical guides, the guides being riveted to the rings in pairs, the outer guide in each pair being wider than, and overlapping, the inner guide.

Between each two pairs of guides slides a loosely fitting steel sheathing plate, secured at its lower end, during sinking, to the cutting edge by cap screws, which are removable from within. Each sheathing plate terminates just above the strainer section and inside the intermediate section, in a strong steel forged eye. The outer and overlapping guides keep the sheathing plates from moving laterally.

At the top of the inner cylinder is a flanged and dished steel head. The intermediate chamber is a cylinder of one-quarter inch steel, which, at its lower edge, overlaps the strainer by six inches, and is fastened thereto by angles and guide strips. At the upper end of the intermediate chamber is a frustrum of cone, which carries a flange for connecting to the bottom of the air shaft.

The outside diameter of the strainer section and of the intermediate section—9 feet—is such that each of them can be built complete at any structural iron works, and then transported on a flat car to the site of the well.

The method of sinking the well, if the pneumatic process is used, is as follows:

The strainer section is set up in place, and the annular space between its two cylinders is filled through the six manholes with washed and sized gravel, the larger stones, —which may be six inches in greatest diameter,—being placed next to the inner cylinder. The size of the outer vertical layers of gravel is regulated by what the test borings have shown to be the nature of the water bearing stratum.

The manholes are closed, and the strainer section is sunk as far as may be easily possible by excavating the material from the inside.

The intermediate section is next lifted by derrick and lowered until the holes in its lower edge come fair with those in the guide strips and angles at the top of the strainer, and the two sections are riveted together. Both sections then constitute a working chamber which is air- and water-tight from top to bottom, except where the upper ends of the sheathing plates pass up, outside the strainer and inside the intermediate chamber. The leaks here may be closed by building a temporary annular brick wall a foot high on the flat plates just inside the eyes of the sheathing plates, and filling the space behind it with coal tar pitch. The top of the strainer section is loaded with pig iron, the air shaft and air lock are connected to the upper flange of the intermediate chamber, and the sinking is carried on by the pneumatic process.

As the top of the intermediate chamber sinks below the surface of the ground, a masonry wall is carried up.

When the well has been sunk to the desired depth, the cap screws which fasten the sheathing plates to the cutting edge are removed and the bottom of the well is covered with clean and sized gravel. The steel plates which are bolted to the inner cylinder are next removed, course by course, beginning at the lowest, and the temporary wall, built to stop the leaks around the sheathing, is removed, and the sheathing plates are pulled up, one by one, inside the intermediate chamber. The two cast iron reducers, the suction pipe and the 12 inch gate are then bolted in

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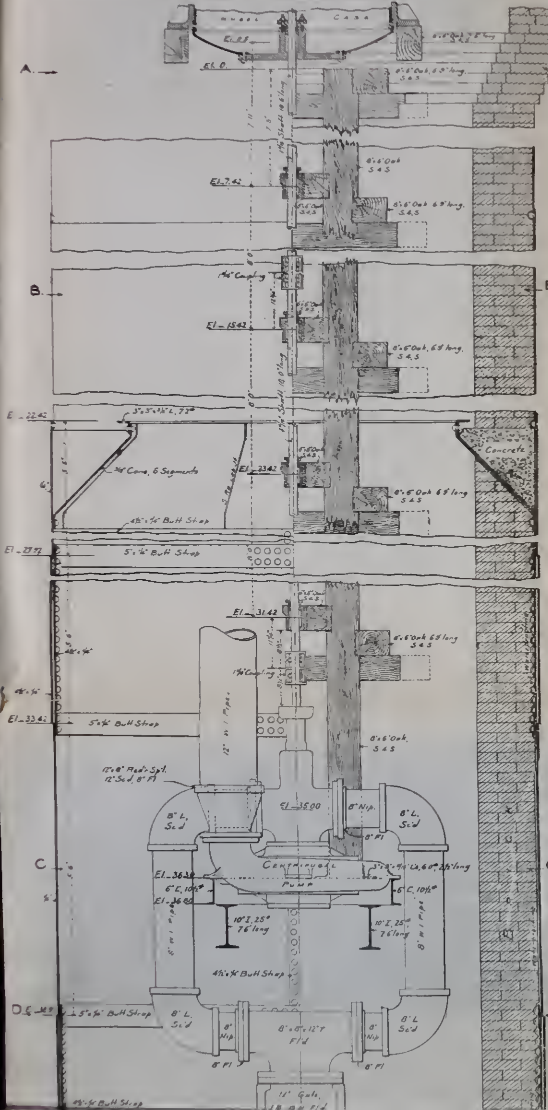
Partial Vertical Section on Line K K — Before Sinking

Partial Vertical Section on Line K K — After Sinking

Pump, Pipes and Shafting shown in Elevation



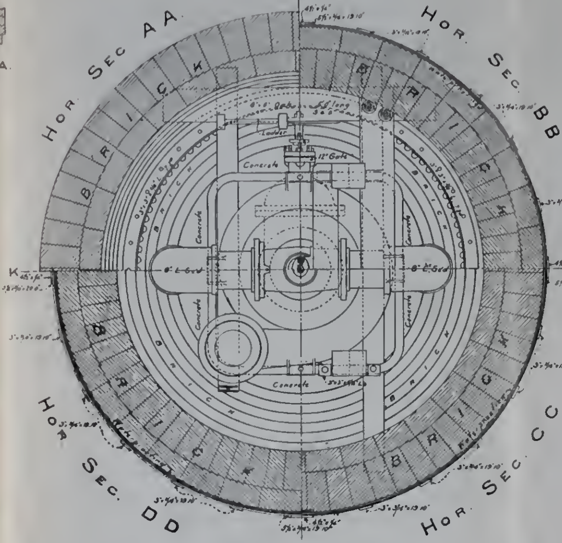
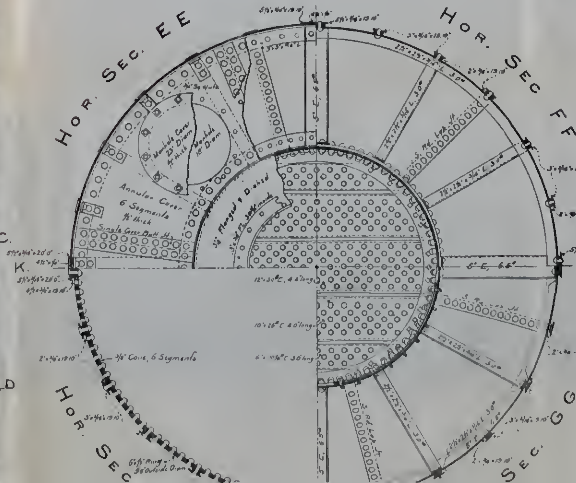


Fig. 2.

Scale 1 inch = 1 Foot.



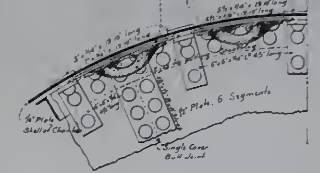


Fig. 12. Partial Hor Sec E E.

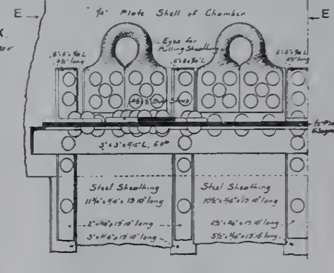


Fig 13 Partial Vert. Elev From Within

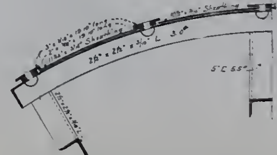


Fig. 14 Partial Hor Sec. F F.

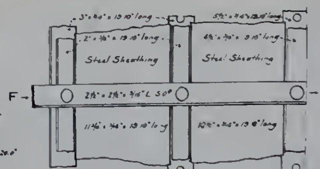


Fig 15 Partial Vert Elev. From Within.

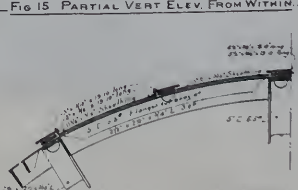


Fig 16 Partial Hor Sec G G

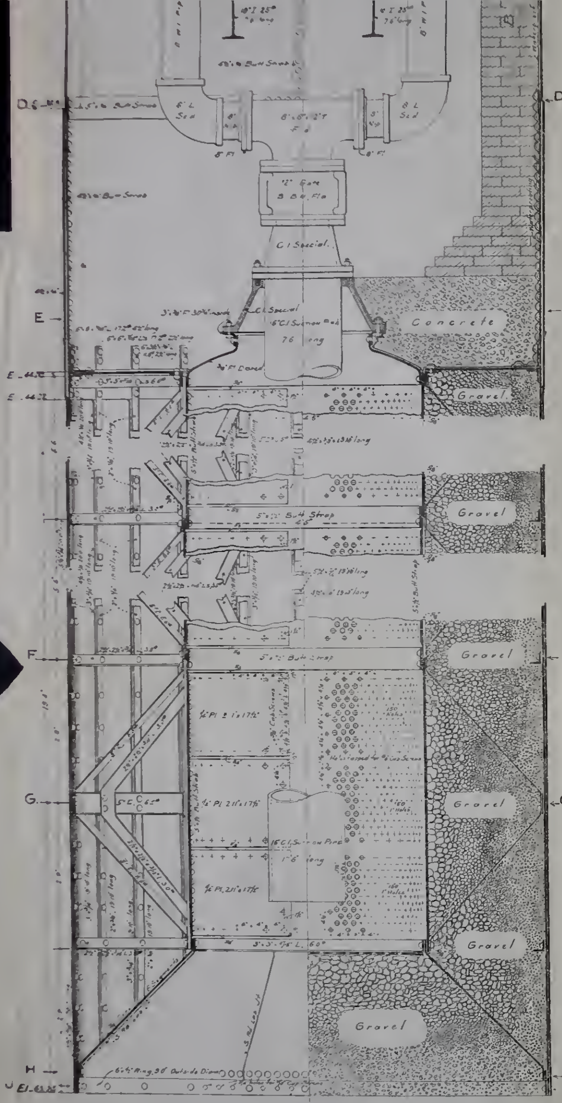


FIG. 1.

SCALE 1 INCH - 1 FOOT

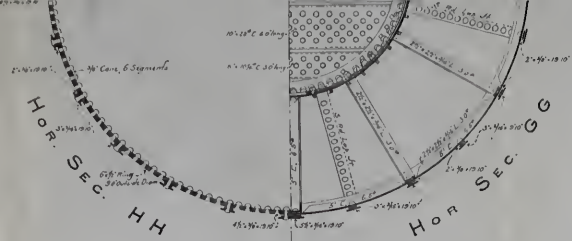


FIG 3

SCALE 1 INCH - 1 FOOT

WELL AND PUMP PIT

DESIGNED BY

DABNEY H. MAURY

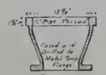
(MEM AMER SOC C.E., MEM AMER SOC M.E.)

CONSULTING ENGINEER

PEORIA, ILL. JANY. 1901

PLATE II.

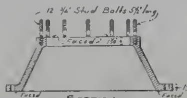
12"x8" REDUCER



SECTION

FIG. 4

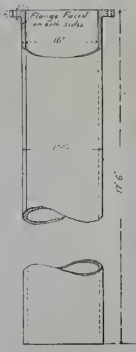
30"x16" REDUCER



SECTION

FIG 8

SUCTION PIPE



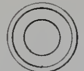


FIG 5 PLAN

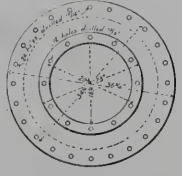


FIG 9 PLAN

16"x12" REDUCER

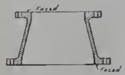


FIG 6 SECTION

FIG. 10 SECTIONAL ELEVATION

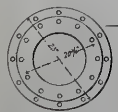


FIG 7. PLAN

DETAILS OF SPECIAL CASTINGS

SCALE 1 INCH - 1 FOOT

Proceedings American Water Works
Association, 1904.

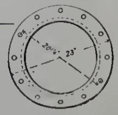


FIG 11 PLAN

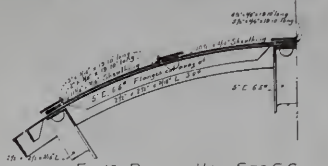


FIG. 16 PARTIAL HOR SEC GG

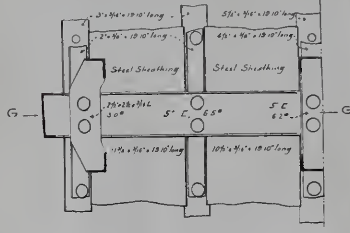


FIG 17 PARTIAL VERT ELEV. FROM WITHIN

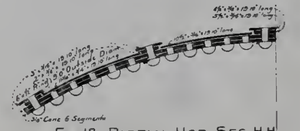


FIG 18. PARTIAL HOR. SEC. HH

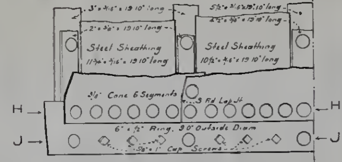


FIG 19 PARTIAL VERT ELEV FROM WITHIN

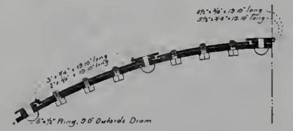


FIG. 20. PARTIAL HOR SEC. J J.

DETAILS OF SHEETING AND GUIDES

SCALE 2 INCHES - 1 FOOT.

place. the bottom of the intermediate chamber is covered with concrete, and the masonry wall is built up high enough inside the chamber to prevent lifting of the concrete floor by the upward water pressure.

The air pressure may then be safely dispensed with, and the 12 inch gate having been closed, the air lock and air shaft are removed and the rest of the work is done in the open air.

This type of well, which is designed more particularly for use where there is practically no gravel in the water bearing stratum, has the following advantages:—

1. Its strainer, being composed of gravel, held back by very heavy steel, is practically indestructible.

2. The strainer cannot clog, for the gravel is finer in the outer than in the inner layers.

3. The capacity of the well is very great, the strainer area being so large, that, assuming only 30 per cent. of voids in the gravel at its outer edge, the velocity of the inflowing water will, when the well is pumped at the rate of five million gallons per 24 hours, be only two feet per minute, or one-thirtieth of a foot per second. This is not sufficient to move the finest sand in any stratum worth serious consideration as a source of water supply.

4. The pump is in a dry pit, always accessible for inspection and repairs, and is set below the normal ground water level, so that no priming is required. There are no joints in the suction pipe below the bulkhead.

5. The well may be readily sunk by the pneumatic process in locations, and to depths, which would render the sinking of an open well by any other process impossible.

6. The first cost is less than that of a well of any other type for use in sand, and of equal capacity.

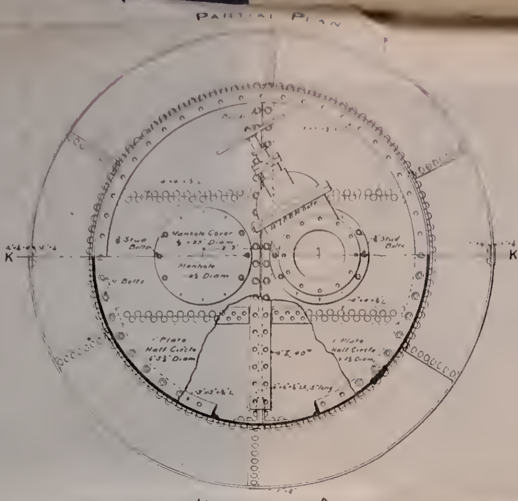
Plate III shows the steel work for the strainer of a well now nearly completed for the Peoria Water Works Co. In this case the water-bearing stratum is coarse sand and gravel, and the strainer consists of a cylinder of ⅝ inch steel 9 feet in diameter by 21 feet 6 inches long, and contains more than 34,000 11-16ths inch holes. These holes are closed while the well is being sunk by steel plates bolted to the inside of the cylinder. At the top of the strainer there is a frustrum of a cone which serves as a foundation for the masonry wall of the upper part of the well, and which carries a smaller cylinder flanged at its upper end to bolt to the bottom of the air shaft. A removable steel bulkhead is also provided.

This well may be sunk either by the pump-and-sink method or by compressed air. In either case the plates covering the strainer holes are removed after the well is sunk, and the finer particles of the water-bearing stratum are washed in with a hose having a nozzle small enough to enter one of the holes. These finer particles may then be pumped out. After all the plates have been taken off, and a gravel strainer formed outside of them, the water-tight bulkhead is bolted on, and the suction pipe, reducer, and gate are bolted in place. The gate being closed, the sinking plant may be removed, and the pump set up and connected.

This well would have even a larger capacity than the one just previously described ; for its gravel strainer would be considerably more than nine feet in diameter. It is simpler in construction, and its cost is less. It would naturally be preferred wherever there is any appreciable amount of gravel in the stratum.

It will be noted that while any type of pump small enough to enter the pump pit may be used in connection with any of the last described types of wells, all these wells have been designed more particularly for use with pumps of what has been commonly known as the centrifugal type.

The writer has for years been impressed with the idea that there was a great deal of room for improvement in the much neglected so-called centrifugal pump, and that



Hor. Sec. AA

—Fig. 1—

—Scale 1 Inch - 1 Foot—

—Partial Vert. Sec. on Line KK— —Partial Vert. Elevation—

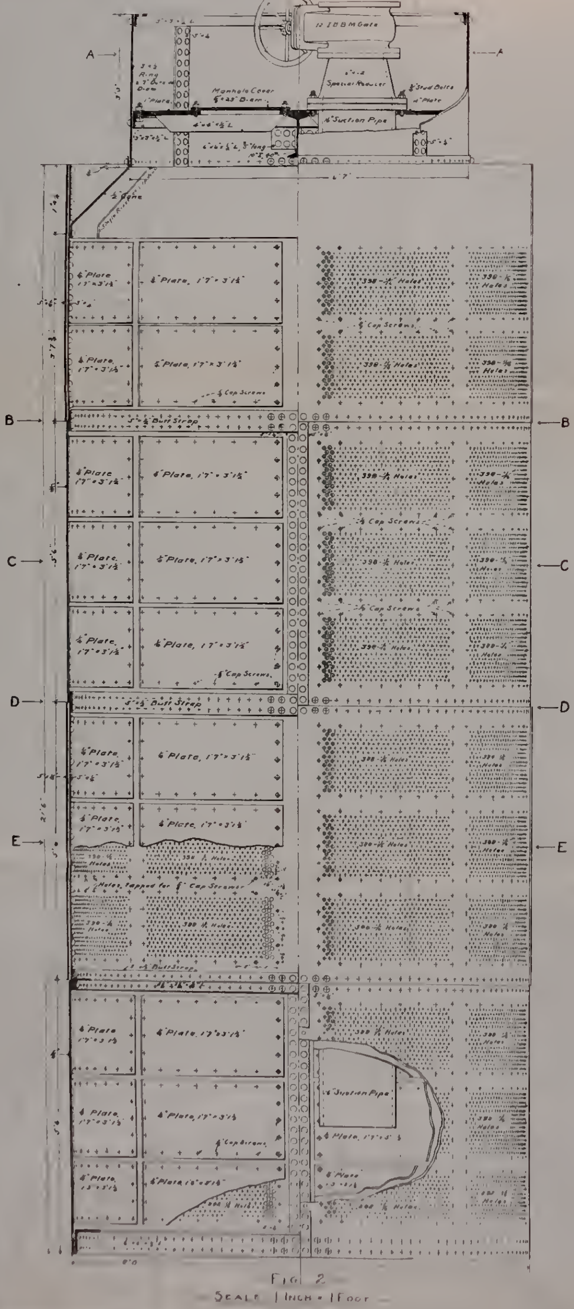
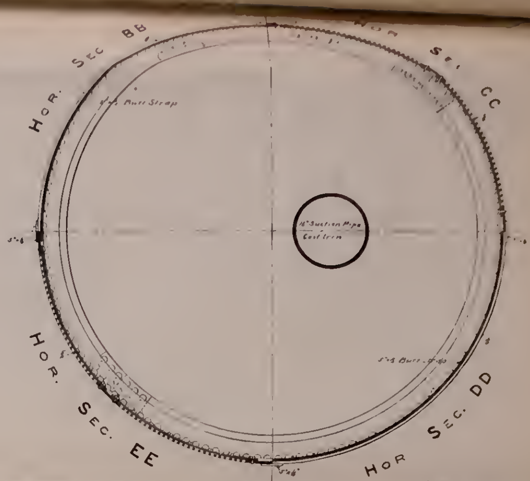


Fig. 2

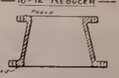
Scale 1 Inch - 1 Foot



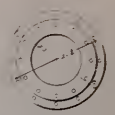
—Fig. 3—

—Scale 1 Inch - 1 Foot—

—16 × 12 Reducer—

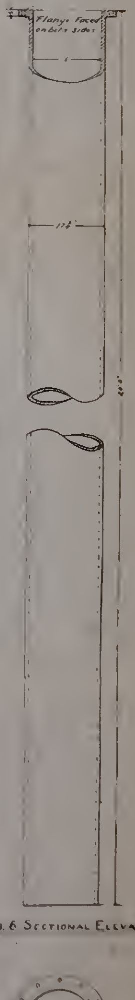


—Fig. 4 Section—

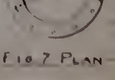


—Fig. 5 Plan—

—Suction Pipe—



— Fig. 6 Sectional Elevation



— Fig. 7 Plan —

—Steel Work—
—and—
—Special Castings—
—for—
—Well Strainer.—
—Designed by —
—Dabney H. Maury, —
—Consulting Engineer,—
—Peoria, Ill., Jan'y, 1903.—

PLATE III.

Proceedings American Water Works Association, 1904.

just as soon as these improvements were made, the pump would come into far more general use.

This idea is now being fully realized, and what the Patent Office calls "Pumps; Subclass, Rotary Single Piston," are at present being designed and built on more rational lines.

The principles governing the construction of a rotary single piston pump should be exactly those governing the construction of a turbine, with due allowance for the fact that the pump, by its rotary motion, is to lift water, while the turbine is to be given a rotary motion by the fall of water from a higher to a lower level.

In the turbine there are stationary guide blades through which the water is directed to the vanes of the moving wheel. Two essential conditions of a theoretically perfectly efficient turbine are that the water shall enter the guide blades without shock and leave the vanes of the wheel without whirling motion relatively to the earth.

In a pump the water should be taken into the revolving wheel, or impeller, without shock, and discharged through the fixed guide blades without whirling motion relatively to the earth. In both turbine and pump the water passages should be as smooth, and as uniform in size, as possible, and they should be so constructed as to cause no abrupt changes in direction of the moving fluid. The more the pump depends on centrifugal action, the less efficient it will be; for the greater the centrifugal action, the more whirling motion there must be in the water leaving the pump. A striking illustration of the losses due to this whirling motion was furnished by the behavior of two pumps tested by the writer about five years ago. The suction and discharge pipes of each pump were exactly like those of the other pump. For equal quantities of water pumped, the suction frictions as shown by piezometer measurements, were the same, while the friction in the discharge pipe of pump No. 1, which depended more on centrifugal action for its work, was from three to four times as great as that in the discharge pipe of pump No. 2. Pump No. 2 was also, apart from the fact that it produced less friction in its discharge pipe, much more efficient than pump No. 1. The greater friction as shown by the piezometers in the discharge pipe of pump No. 1 was doubtless due to two causes:

1. The centrifugal force in the whirling water entering the base of the discharge pipe exerted a fictitious and excessive pressure on the piezometer tube at that point; and

2. As the whirling water traveled upwards in its longer spiral path, the friction was naturally greater than that caused by the water flowing with less whirling motion from pump No. 2.

It is the application of these principles, almost within the last year, to what has been, but should no longer be, called the "centrifugal" pump, that has resulted in developing it at last into a turbine pump, suitable for high lifts, and capable of relatively high efficiencies. As this pump, properly designed for its service, is the cheapest, simplest and most compact pump known to modern science, a brief discussion of the present state of the art may not be amiss.

The essential parts of a pump of the rotary single piston type are the shaft; the rotary piston, or runner, or impeller, as it is variously called; the case surrounding the impeller; and the openings provided for the attachment of suction and discharge pipes to the case. The old style centrifugal pump had no guide blades for absorbing the wasted energy in the whirling water as it left the impeller. A properly designed modern pump has these guide blades and thus becomes practically a reversed turbine.

The impeller may either be of the open type, with vanes on one or both sides of the disc which carries them, or it may be of the hollow or closed form, the vanes being contained between two discs, one of which has a suction

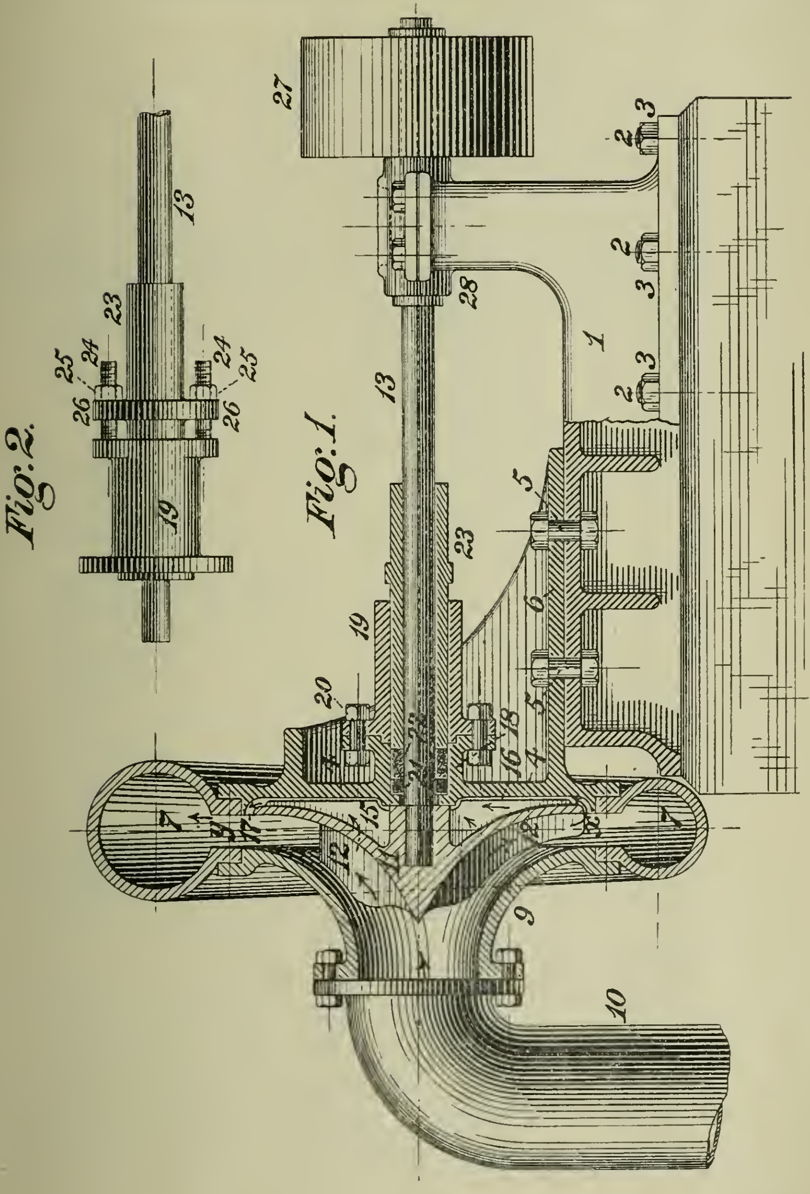


Fig. 2.
Fig. 1.

PLATE IV.

opening in its center. With either type, the hydraulic pressures resulting from the motion of the impeller cause an end thrust which tends to force the disc towards the suction side of the pump.

A number of devices for balancing this end thrust have been patented. As these devices are often different for the different types of impellers, the next few reproductions of Patent Office drawings, which illustrate several methods of balancing the end thrust, will at the same time show the several types of impellers.

Plate IV shows an open impeller, consisting of a disc, 11, keyed to the pump shaft, and having the vanes, 12, which set the water in motion, fitting closely to the pump case on the suction side. If the disc, 11, had no holes through it, nor vanes on the side away from the suction pipe, the entire area of that side of the disc would be subjected to a pressure per square inch equal to the discharge pressure; while the pressure on the opposite, or suction, side of the disc would vary from the suction pressure, or partial vacuum, in the central portion of the disc, to the full discharge pressure at its outer edge. The resultant of these pressures tends to force the impeller towards the suction pipe; and to prevent this, the inventor perforates his disc near its center, and by the addition of small vanes, 15, on the opposite side, creates a centrifugal action on that side of the impeller which produces a pressure varying from suction pressure at the center to discharge pressure at the circumference, in a manner similar to the action of the principal vanes, 12.

Plate V shows two pumps whose impellers have small discs with vanes on one side of them, and extending out beyond the discs. Here the inventor has a piston which turns with the shaft in a cylinder, and by admitting water at discharge pressure to one side of this piston, and connecting the other side to the suction pipe, a pressure is set

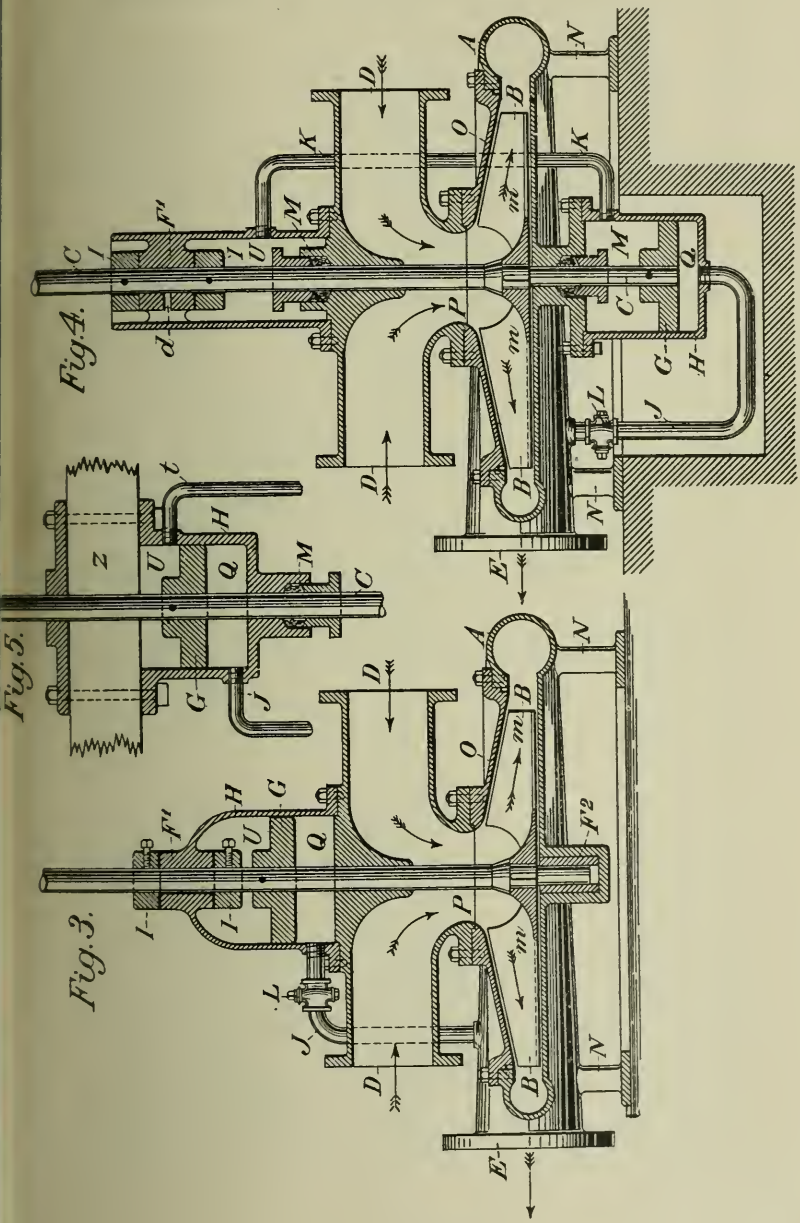


PLATE V.

up which may either add to, or reduce, the thrust of the shaft, according to the side of the piston to which the discharge pressure is applied. In the pumps shown the pressure set up by the impeller acts in same manner as that on the balancing piston, i. e., upwards, doubtless with a view to sustaining the weight of the rotating parts.

Plate VI. shows two other applications of the same balancing piston. This time the impeller is of the closed or hollow type. As the pressures between opposite portions of the two discs of this impeller are equal, while the entire outside area of each disc, except the area of the suction inlet, is subjected to the full discharge pressure, it follows that there would be an end thrust equal to the area in square inches of the suction inlet multiplied by the difference between the discharge and suction pressures. Here again the pressure on the balancing piston is added to the natural end thrust, to carry the moving parts.

Plate VII. shows a hollow runner pump in which the lower part of the hub has passages, P, to admit the water at suction pressure, or partial vacuum, below the end of the hub, thus reducing the end thrust to some extent. By making the hub larger, the thrust may be still further reduced.

The device for sealing the packing gland, K, against air leaks, by the combination of the chamber, H, with the pipe, I, leading from the discharge pipe, is also worthy of note.

Plate VIII. shows an ingenious device applied to the same type of impeller, for automatically balancing the resultant of the upward thrust and of the downward weight of the moving parts, in such a manner that the moving parts may be said to be floated. Here is shown a hollow runner with a hub, H, of large area, cast on it, and turning inside of the vertical flange, H^1. There is a plug, J, which projects into a central hole, I^1, in the

Fig.1.

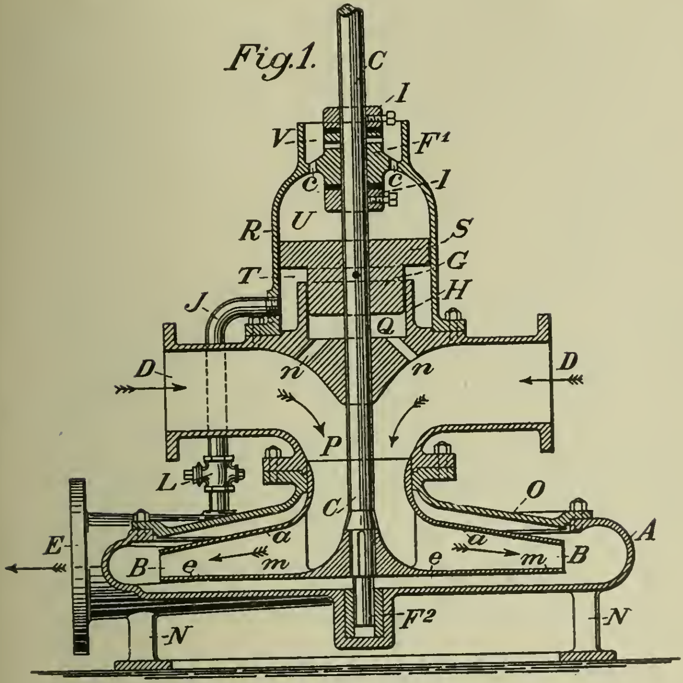


Fig.2.

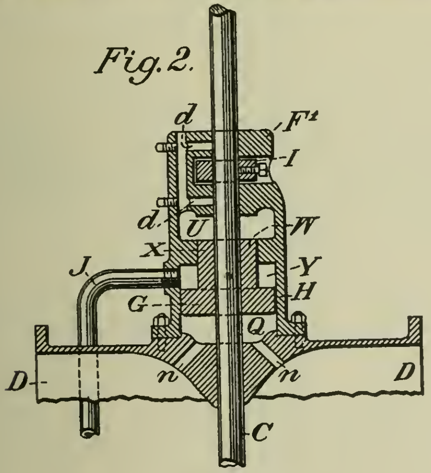


PLATE VI.

hub, to which hole, I^1, water from the inside of the impeller, and at suction pressure, has free access. A slight vertical play is permitted in the moving parts. If the plug, J, by the upward motion of the hub, is withdrawn from the hole, I^1, the water under the hub is practically

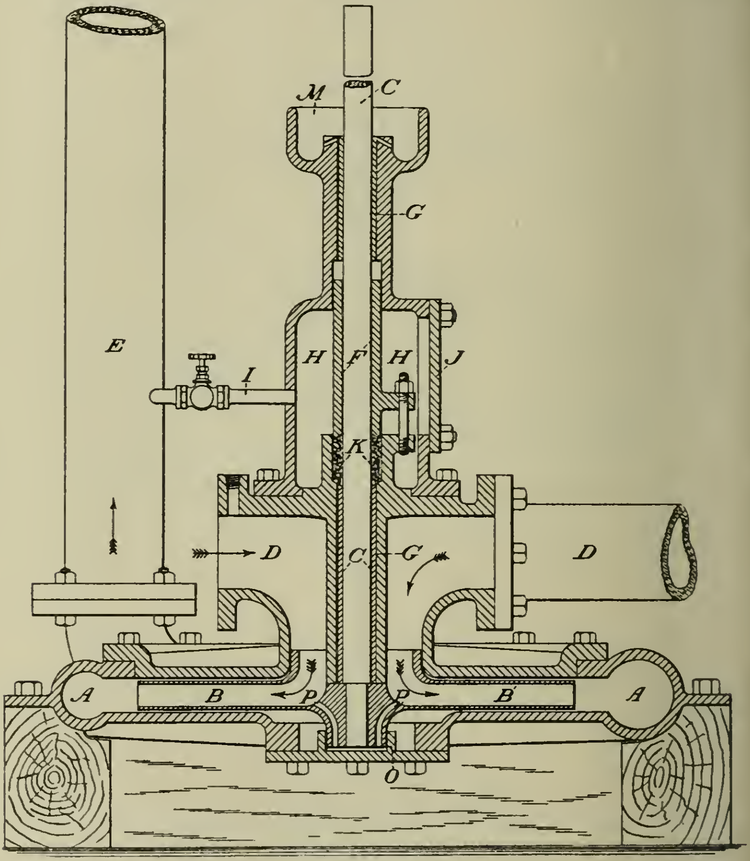


PLATE VII.

at suction pressure, tending to balance the natural upward end thrust. If the hub settles down, so that the plug, J, fills and closes the hole, I^1, then the bottom of the hub is

Fig. 1.

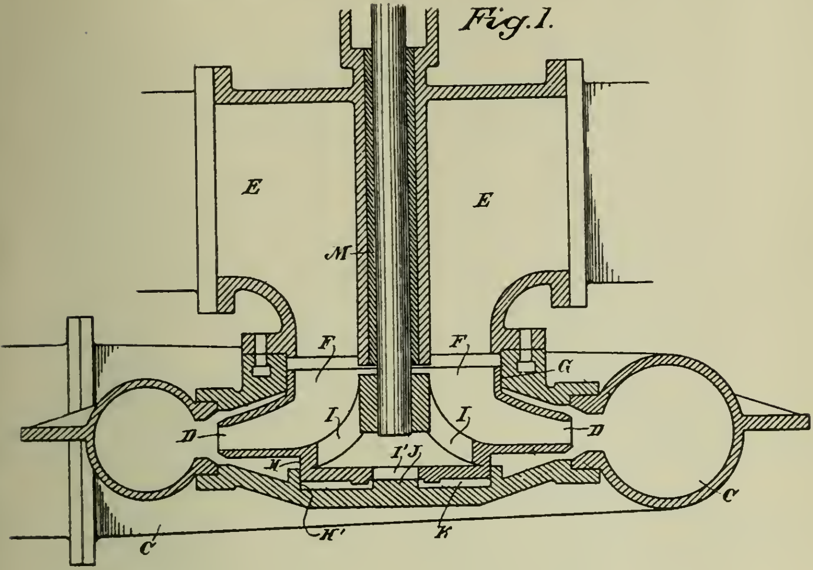


Fig. 2.

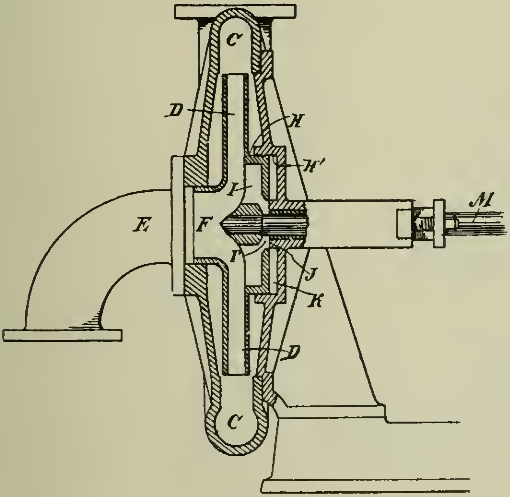


PLATE VIII.

Fig: I

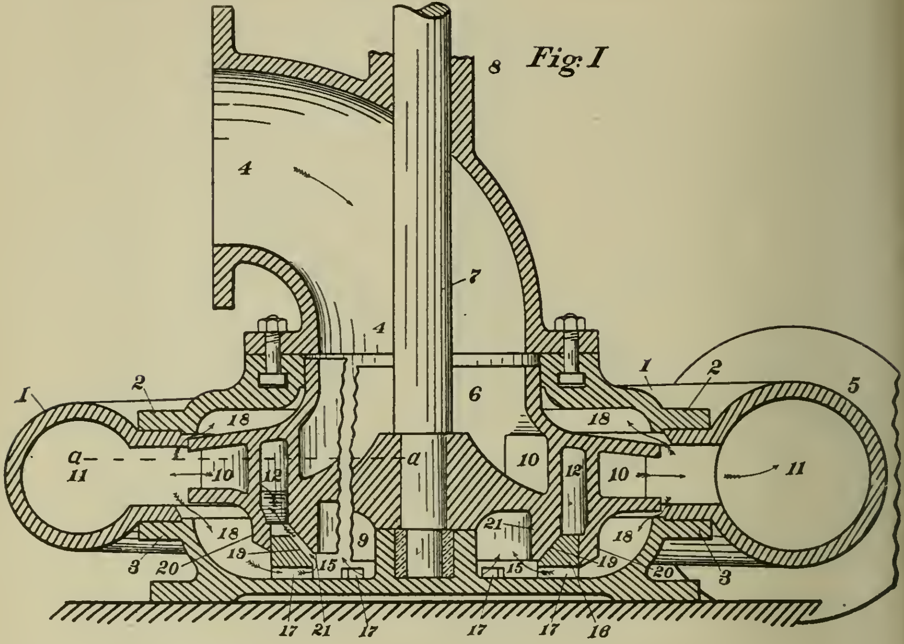


Fig: II

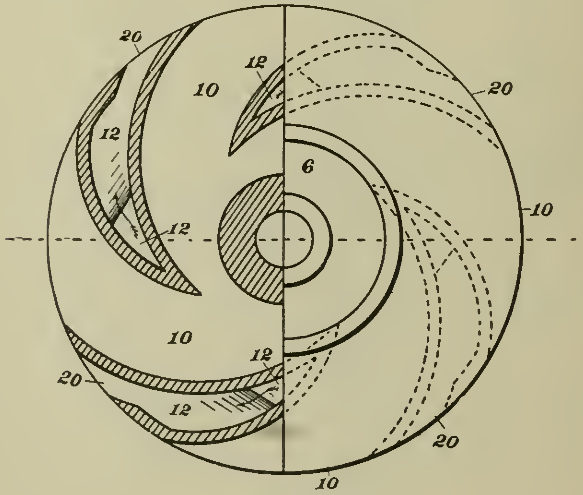


PLATE IX.

subjected, by leakage between the flange, H', and the outer surface of the hub, to the discharge pressure, thus increasing the up thrust. It will be seen that a very slight end play will suffice to keep the moving parts in balance.

Plate IX. shows another hollow-runner pump which depends upon end play for automatic balancing. Some of the principles involved are the same as in the last pump shown, though the construction is more complicated. In the drawing the impeller is shown broken, the left half being up, and the right half down. The impeller has two sets of passages, the regular working set, marked 10, and a second set, marked 12, having openings through the bottom of the hub, these passages being used for the balancing effect only. When the impeller rises, the upthrust is diminished by the opening of the annular passage, 15, which brings into action the passages, 12, and reduces the upward end thrust. When the impeller sinks to its lowest position, this annular opening is closed, and

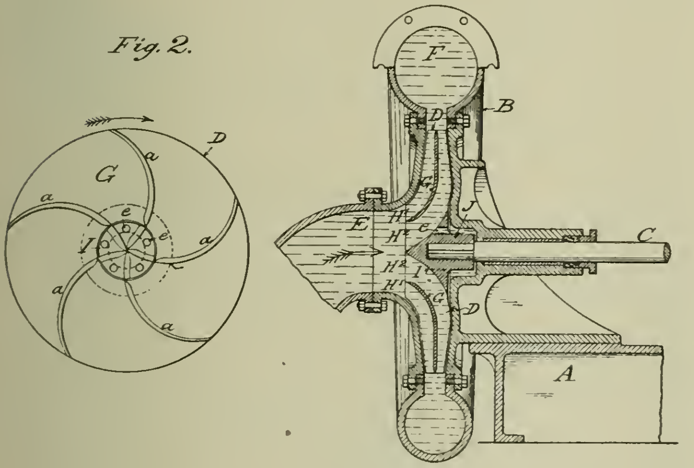


Fig. 2.
Fig. 1.

PLATE X.

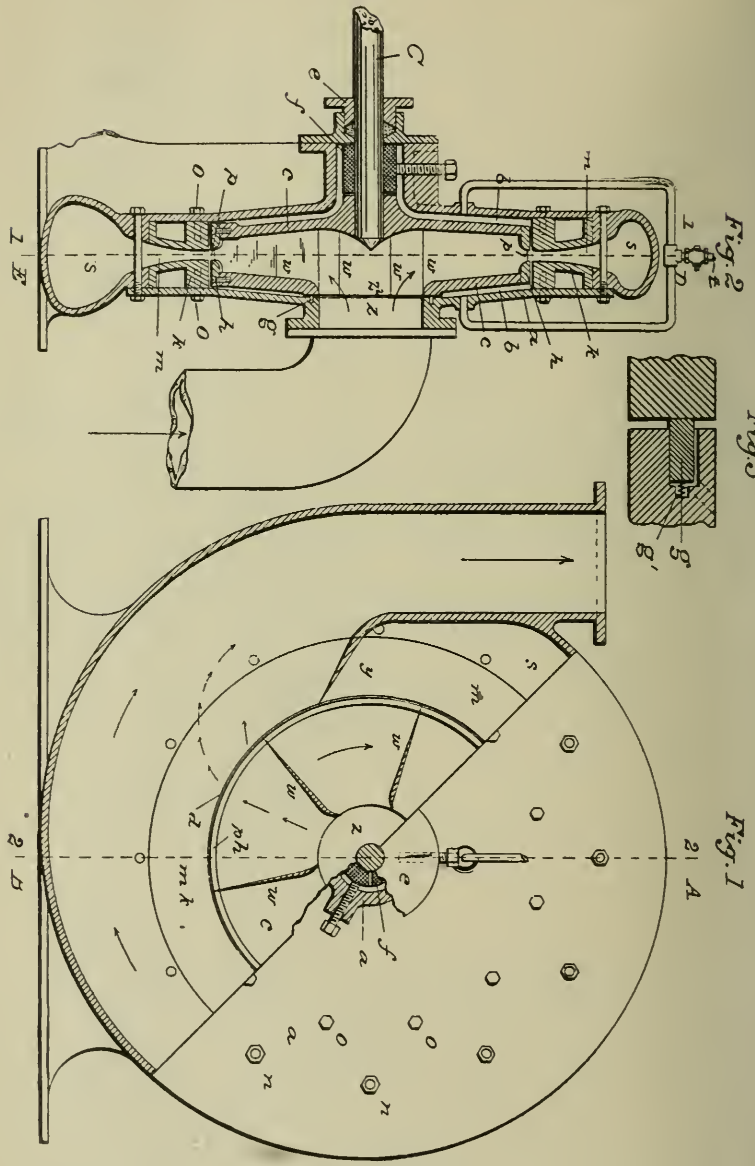


Fig. 2
C
e
f
o
p
c
b
n
1 E
1
s
D
E
w
z
z²
g
a
k
m
Fig. 3
g
g'
Fig. 1
2 A
2 B
y
m
s
w
d
ph
mk
c
e
a
f
z
o
r

PLATE XI

the end thrust becomes that due to the full unbalanced pressure on the area of the suction opening.

In the pump shown on Plate X., the balancing is effected by the use of an open impeller which has its disc in about the center of its vanes, the disc itself having an opening in its center of about one-half the area of the suction inlet, while water at the suction pressure is admitted to the base of the small hub by passages through the hub close to the shaft.

Plate XI. shows a pump in which the inventor utilizes the vacuum-producing effect of a jet to reduce the pressures on both sides of a hollow impeller, in order, as claimed by him, to reduce the friction between the moving impeller and the water outside of it, and between this water and the walls of the case. To produce the jet, the discharge outlet at the rim of the impeller, and the throat way which receives the water from it, are fashioned to a cross section resembling that of an injector, or a Venturi contraction. It is hard to see why more is not lost than is gained by this construction.

Plate XII. shows a series pump, having a number of impellers on the same shaft. There are two suction pipes, one on each side.—a very common device for balancing end thrust, and the suction inlets on the impellers on the right hand side face to the right, while those to the left face to the left. The common discharge pipe is in the center. Each impeller in each series discharges at its periphery into an annuler passage which returns the water to the center, where it enters the suction inlet of the next impeller in its series. In this way the lift of the pump may be multiplied to any desired head.

The next pump, Plate XIII., has no case surrounding the impeller, which is of the hollow type, and rotates with its periphery opposite to a fixed discharge chamber, or volute casing. This casing is provided with guide blades, 6, or diffusion vanes as they are called, designed to in-

Fig. 2.

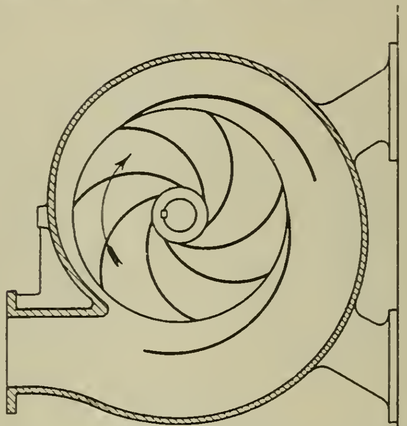


Fig. 1.

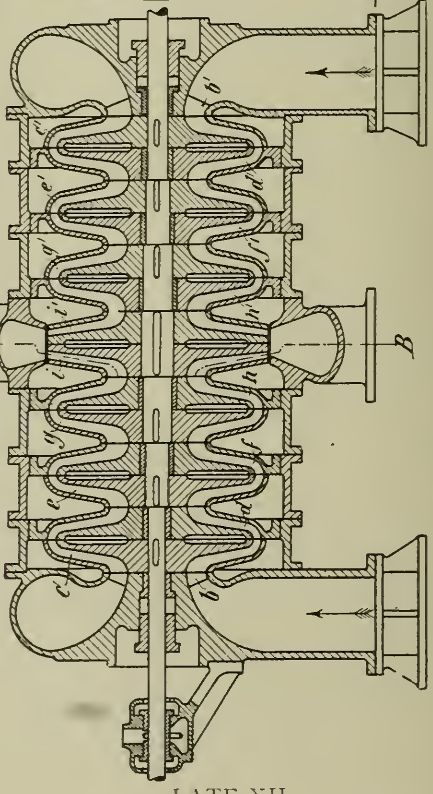


PLATE XII.

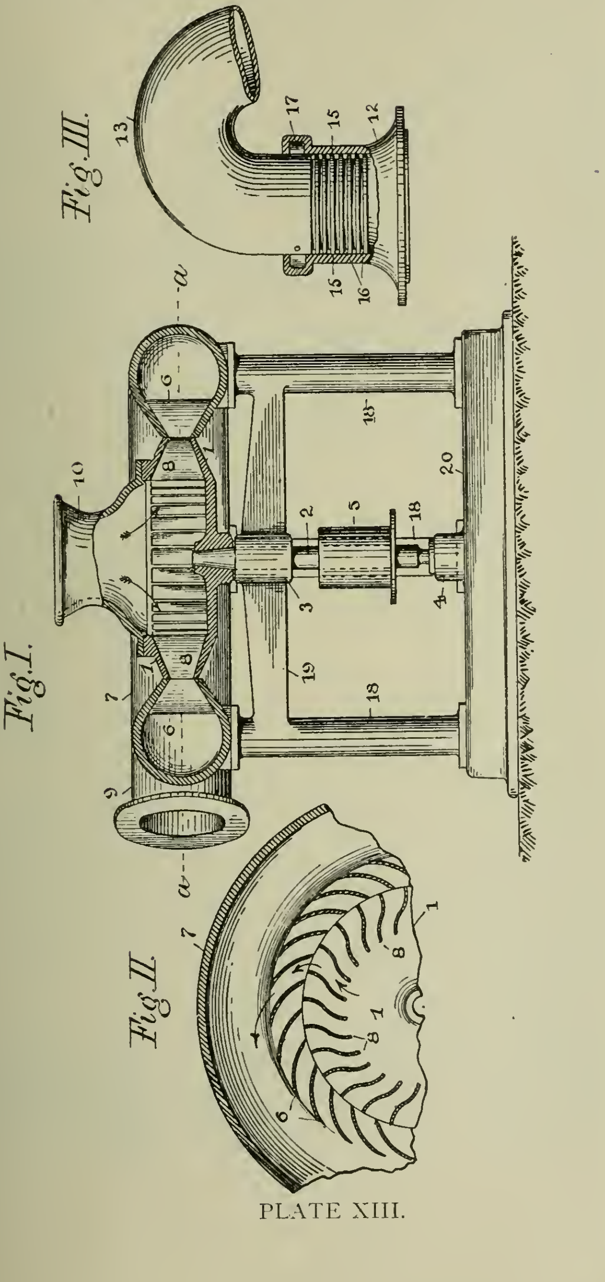


PLATE XIII.

crease the efficiency of the pump. As a matter of fact, it is evident from the drawing that these guide blades are incorrectly designed, as they tend to send the water whirling around the volute casing, in the direction of the arrow, instead of delivering it into this casing, dead and without whirling motion.

Plate XIV. shows a design in which there are two sets of guide blades combined with a hollow impeller, and an annular discharge chamber, 31, located above the impeller, its lower walls forming part of the upper wall of the pump casing. One set of these guide blades, 20, delivers the water into a returning annular passage, 30, which brings it back towards the center, and then through the next set of guide blades, 29, into the discharge chamber. Again the guide blades, 20, are incorectly designed.

In Plate XV. we have a series pump, with hollow impellers, b_1, b_2, b_3, b_4,— in two pairs on the same shaft. The two impellers in each pair balance each other. Each discharges through guide blades, h_1, h_2, h_3 and h_4, respectively.

The impeller b_1, takes its water from the suction pipe S, and discharges it into the annular chamber I_1; whence, following the course of the curved arrow, it passes across through openings between the guide blades h_1, into the passage F_2, and thence to the suction inlet of impeller, b_2. The impeller, b_2, delivers it into the chamber I_2, which is connected to a discharge pipe provided with a gate. If the gate on I_2 is open, and the gate on I_4 is closed, the water goes on out the discharge pipe, I_2, with only the pressure imparted to it by the impellers b_1 and b_2 working in series. If the gate on I_2 is closed, and the gate on I_4 is open the water continues its devious wanderings through passage, F_3, into impeller, b_3; through guide blades, h_5, into annular chamber, I_3; thence across through openings between the guide blades to the suction side of im-

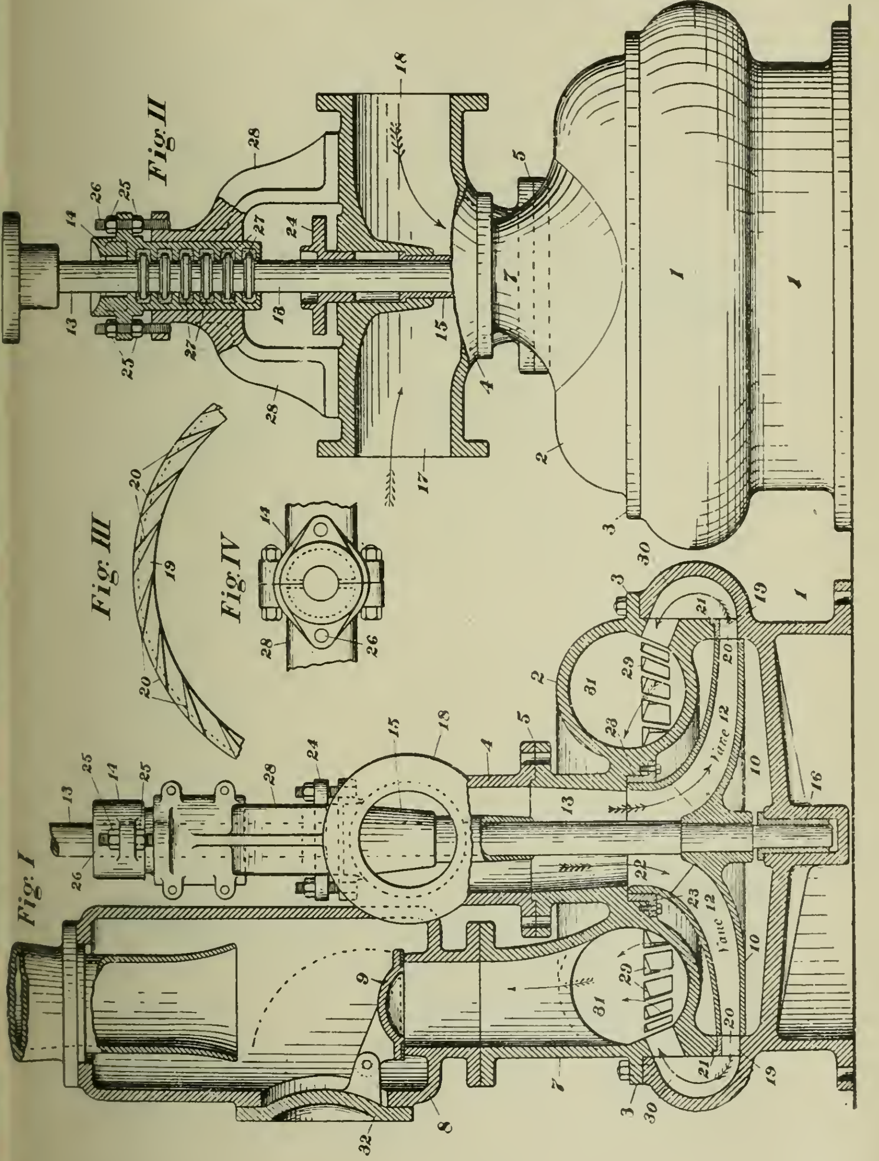


Fig. I
Fig. II
Fig. III
Fig. IV
Vane 12

PLATE XIV

Fig. 1.

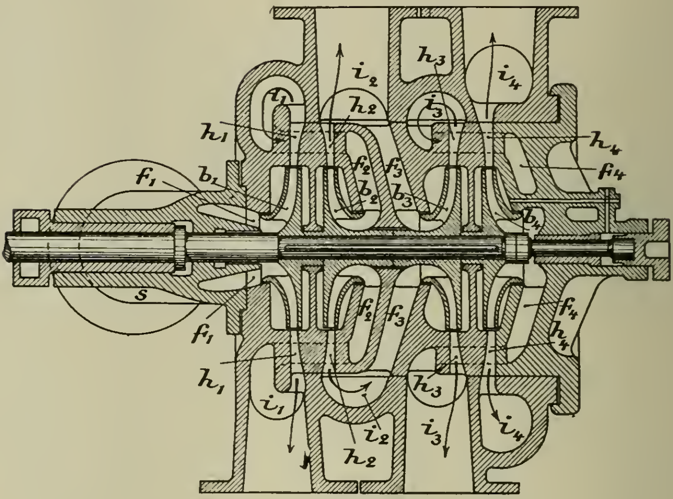


PLATE XV.

Fig. 1.

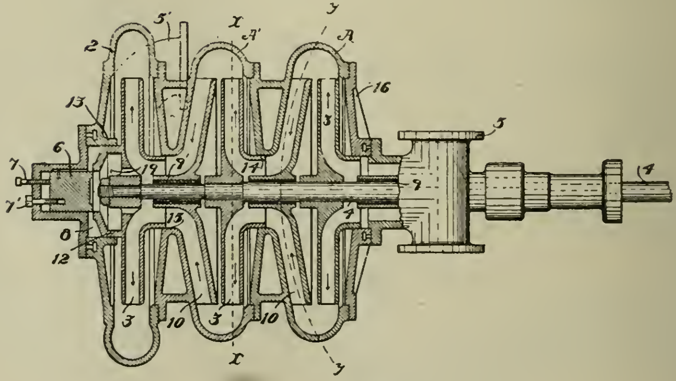


PLATE XVI.

peller b_4; through this impeller to the discharge chamber, I., which it enters with the pressure due to all four impellers working in series.

Apparently the inventor's chief claim in this patent is meant to cover the ability to vary the lift of the pump, without varying the speed, by means of opening or closing the gates on the different discharge pipes.

Plate XVI. shows a series pump, having hollow impellers, each of which, except the last in the series, discharges into an annular passage which curves backwards towards the center, so as to deliver the water from one impeller into the suction inlet of the next. The inwardly retuning portion of the passage is fitted with guide blades, 10, to absorb the whirling motion of the water. There is a balancing device identical with that shown in Plate 14, except that the plug, 6, is movable, and can be so adjusted from the outside by the cap screws, 7, and while the pump is running, that the point of equilibrium of the moving parts may be set at any desired elevation.

Plate XVII. shows a series pump having two hollow impellers balanced by being set with their suctions facing in opposite directions. One impeller discharges, through the passages, 19, into the suction of the other. This pump is provided with a ring, 14, carrying guide blades, or "diffusion vanes," 26, shown in detail in Figures III. and IV. Here again we see the same incorect design for guide blades.

Plate XVIII. shows a pump like the last one, except that the suction inlets of all the impellers are on the same side, and the end thrust is balanced by a piston, 14, supplied on one side through openings, 35, with water from the discharge pipe, the cylinder having a drain cock, 36, in its other end, by means of which the pressure in that end, due to the water leaking past the piston, may be regulated. There are also a ring, 15, carrying guide

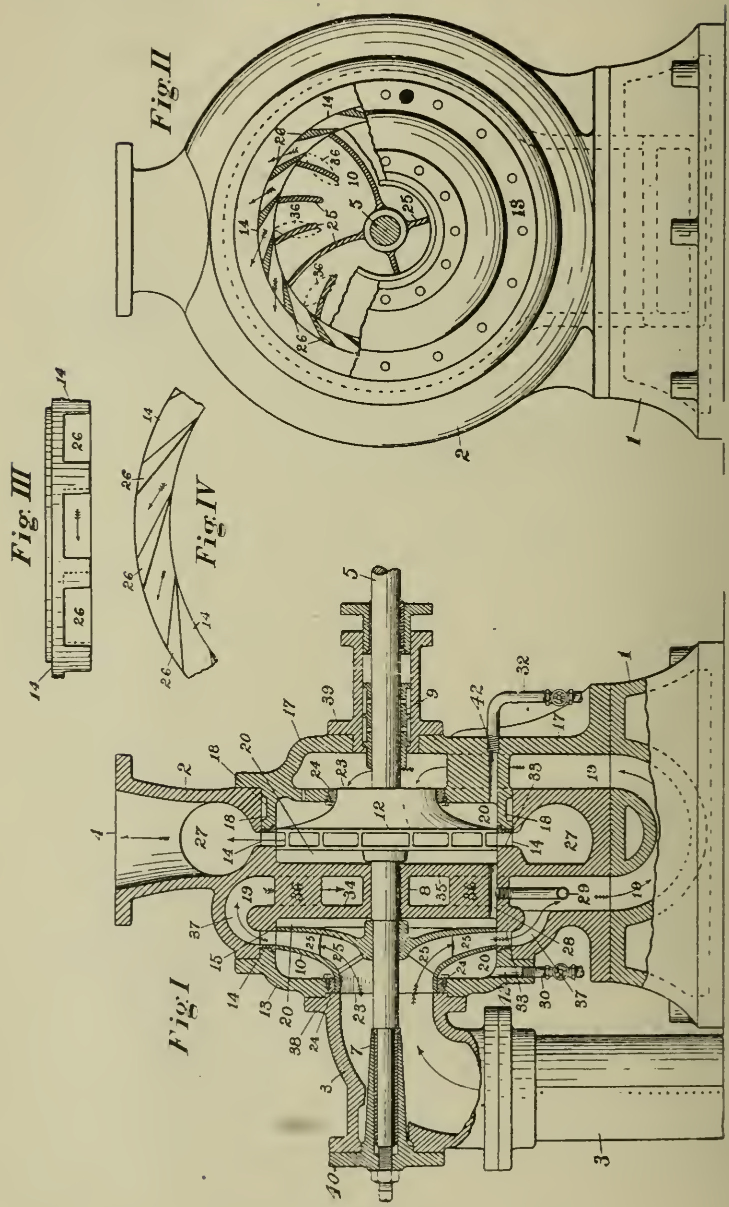


Fig. I
Fig. II
Fig. III
Fig. IV

PLATE XVII.

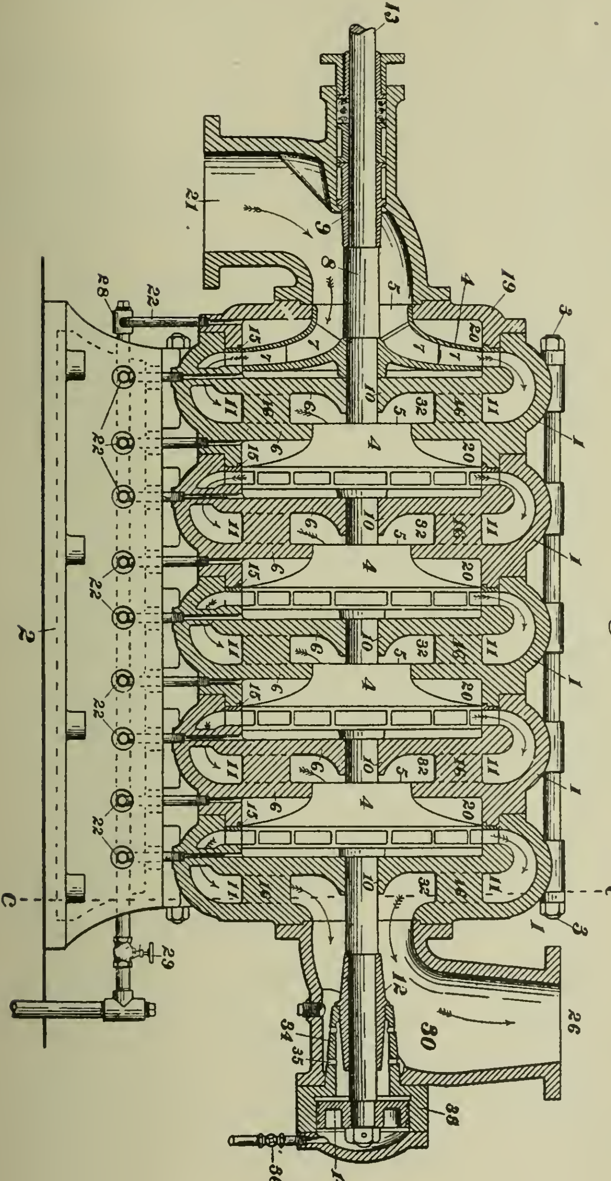


Fig. I

PLATE XVIII

blades, opposite the periphery of each impeller, and another set of guide blades, 16, in the passage which returns the water from the circumference towards the center.

Plate XIX. shows a pump which differs chiefly in details of construction from the last one described. There are a series of impellers, a balancing piston, and two sets of guide blades. There is, however, an additional balancing device, unlike any hitherto shown.

It will be seen that in each impeller the disc carrying the suction inlet is larger in diameter than the other. As the pressure in the water between the two discs increases from center to circumference, it follows that the smaller disc, behind which the water is admitted at a point nearer the center than is the case with the other, will have less pressure per square inch acting behind it. The difference between the pressures behind the two discs tends to neutralize the end thrust due to the unbalanced suction area.

The foregoing sixteen plates of Patent Office Drawings have been selected from about three hundred patents on Rotary Single Piston Pumps, the earliest of which was issued in 1832. While there are some "freak" pumps among them, there are none which compare in absurdity with the majority of the patented pumps not shown. All of the sixteen patents shown are of comparatively recent invention, only one patent having expired.

The advantages of the turbine pump are:

1. Small first cost.

2. Extreme simplicity. There is but one moving part, and that is in rotary motion.

3. Durability. The wearing parts are practically limited to the shaft and its bearings.

4. Compactness. A pump of 15 or 20 million gallons capacity can be set on a vertical shaft in a pump pit seven feet in diameter, which means a great saving in cost of foundations and setting.

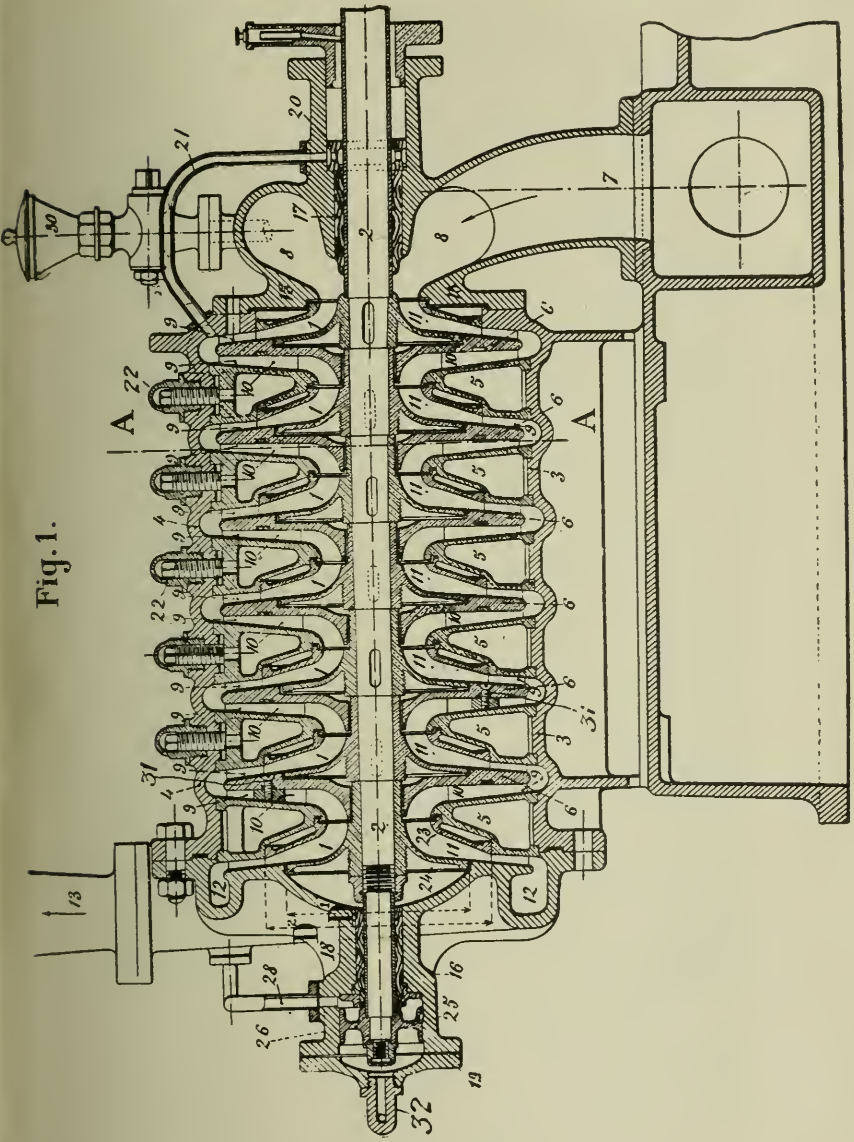


Fig. 1.

PLATE XIX

5. Adaptability for connection to any type of driving engine or motor.

The efficiency of well designed turbine pumps ought to be as great as that of turbines of the same horse power. The writer can see no reason why pump-makers, after they shall have had a little more experience with these new pumps, should not realize as high as 85 per cent. efficiency, and possibly, in exceptional cases, even more.

There are now several manufacturers who are prepared to build turbine pumps of almost any capacity, and for any lift up to 1,000 feet. As further illustrating the range of the field of usefulness of turbine pumps, the writer is now working on plans for the following:

Pumps for use in 10″ and 12″ driven wells, to take water at 100 feet below the surface, and deliver it 120 feet above the surface.

Pumps of capacity of two million gallons against a head of 575 feet.

Pumps of six million gallons capacity against a head of 700 feet.

Pump of twenty-five million gallons capacity against a head of 200 feet.

In conclusion, the turbine pump may be said, after seventy years of groping and bungling, to have at last suddenly arrived. During the past few years the steam turbine has leaped into prominence as a competitor of the reciprocating steam engine, and history is already repeating itself. That ponderous giant, the reciprocating steam pumping engine, must now reckon with the diminutive turbine pump, which will, in many instances, play David to the former's Goliath.

PRESIDENT SHERRERD: We shall shortly adjourn to the regular hall in the Exposition Building; but before doing so, as the lantern slides are here, if there is any discussion on this paper, perhaps it would be well to take it up now. It seems to me that the Association is indebted to Mr. Maury for the able manner in which he has presented this subject, which is one of very great importance in the future of water works development. The Chair would be glad to hear any discussion.

MR. GOODELL: I would like to say that I think the Association is under a great debt of gratitude to Mr. Maury for his going into this matter so carefully, possibly because more years ago than I like to remember it was my good fortune to sit at the feet of a very learned Gamaliel in Switzerland who. in his best moments, could start up there in the northwest corner of that sheet and end up in the southeast corner with a formula for designing the impellers of a centrifugal pump. That was the theoretical side that was developed over there first in Europe. The last pump, if I remember rightly, that was thrown on the screen was Ratteau's pump. He is in the city to-day, and I am sorry he is not here to explain something about that pump to you. He could explain how they started with that theoretical side over there, and have been working forward in a practical way and getting these higher efficiencies that they are now obtaining. As a matter of fact, the development of these centrifugal pumps is coming very largely along just the lines that Mr. Maury has pointed out. The practical men and theoretical men are working together hand in hand, and they are going to produce a machine that will be extraordinarily efficient as compared with the pumps built fifteen or twenty years ago.

As I said before, I think that the Association is under a deep debt of gratitude to Mr. Maury for going into this matter so very thoroughly, and I move that a vote of thanks be tendered to him.

MR. ALVORD: I have had considerable experience with centrifugal pumps myself. I started out in the employ of a railroad company in Chicago to develop a deep well centrifugal pump, at their request, about two years ago—one that would be put into rotation at high speed and raise water to the surface or above it. After developing a practical balancing device by which the down thrust was entirely removed from the shaft and impeller, and which was successfully put into operation, we next proceeded to try and develop a vane which would raise the water with the greatest amount of efficiency, and after going all through the range of mathematics and theory of centrifugal pumps, and spending a good deal of midnight oil, I developed several types of vanes which seemed to me to accord with the practice of centrifugal pumps as I found it in the text books. The results obtained afforded us a tremendous amount of mortification and disappointment. We then started out in the most blind and empirical fashion to guess what we might do. After trying seventeen different impellers, each with different forms of fixed vanes leading to and from them, and under variations of conditions for each impeller, each one of which was practically a guess built up from the information derived from a preceding experiment, we at last approximated a form of vane different entirely from any theoretical form which we had started out with, and which seemed to give us a reasonably good efficiency. We were checked in our experiments by the failure of the railway company to further prosecute them, owing to financial conditions. There is evidently, however, a still further field for exploration along the same lines on which we were proceeding which might increase efficiency.. I would say, roughly speaking, we got up to an efficiency of 55%, raising water out of a 10" well at the rate of about 1,500 gallons a minute to a height of 30 or 40 feet, for a single stage pump. Of course, by duplicating the pump, we could multiply the heighth. The whole thing illustrates the misconception upon which the theory and practice of centrifugal pumps has been founded for many years. There are a good many variables to centrifugal pumps, more than it is practicable to deal with in a limited range of experiments. No one but a pump builder who has unlimited means, such as the Sulzers of Switzerland apparently have had, can afford to go through the vast number of experiments which are necessary to slowly build up, step by step, the proper form and arrangement of these pumps. As you all know, the pump builders of this country have been working on this problem assiduously for the last two or three years, and I suppose a large amount of useful information has been collected on this subject by them, which, of course, naturally, they are not imparting to the general public at this time. But I look to see in the very near future the water works machinery of the present largely displaced by rotating machinery of the kind that we have been viewing upon the screen this morning. This may seem a bold prediction, but I think that anyone who has given the subject intelligent attention for the last two or three years, would hardly fail to agree with me that it is a comparatively safe assertion.

MR. BOARDMAN: In seconding the vote of thanks which we wish to give to Mr. Maury, and which he deserves, while on my feet I wish to say that there is a practical phase of the question which was not brought out in his paper, but which he, of course, is familiar with, and to which I would like to call your attention. We all know that the greatest efficiency to be derived from the centrifugal pump is to be found only under the conditions for which it is designed, that is, under the pressure and with the volume for which it is designed it is more efficient than if at a greater pressure put upon it or a lesser amount of water sent through it under the same pressure for which it was designed. In most of the water works there is a difference of pressure desired when a fire occurs over that of ordinary pumping. You have noticed in the drawings that by delivering from one of those units to the other connected to the same shaft the pressures are increased. A corresponding increase of pressure is obtained by delivering from one of these pumps to another run by a different shaft or engine. A practical suggestion is to have a pump designed for the particular pressure and quantity suitable for your regular work, and then by a separate machine to build up the pressure during those hours when you wish to increase your pressure for fire purposes. It is that phase that I wish to bring forward, which is quite an important and practical one for water works practice, and one which is going to add largely to the popularity of this kind of pump.

I second the motion to tender a vote of thanks to Mr. Maury.

Mr. Gwinn: Recently we had occasion to figure on a centrifugal pump for low service work where the maximum suction lift was about 15′ with a total lift of 65′.

I had an idea that a centrifugal pump would not work properly unless it was placed on a level with the water. I had a conference with the Byron Jackson Machine Works, San Francisco, and finally made a contract for a 12″ Jackson pump to be operated with a Williams vertical engine made by the Quincy Engine Works. The engine is to be set on the floor and the centrifugal pump in a pit 21′ deep, the power being transmitted by a rope drive. The guaranteed duty is 75,000,000 on a steam basis. The pump builders guarantee 70% efficiency for the centrifugal pump, but state that we will probably get 75%.

In my conference with the Messrs. Jackson I was compelled to change a good many of my preconceived notions about centrifugal pumps, and was assured that one cannot find information about centrifugal pumps in books, but that most of the knowledge on the subject is located under the hats of the manufacturers. I asked for a catalogue and was handed a sheet of paper about twice the size of a letter head. It was seen from this that the manufacturer is not willing to give his knowledge to the general public, but retains it for each individual case. I was informed that they could design a pump which would work satisfactorily with a suction lift of 20′ and that pumps could be designed to work against any head.

MR. IRVING H. REYNOLDS (by letter): Mr. Maury's paper is interesting, as presenting one solution of the problem of obtaining efficient and reliable pumping machinery for a certain class of wells.

In the discussion it has been suggested that the centrifugal pump—perhaps in connection with the steam turbine —might become the pumping engine of the future.

Viewed from my standpoint as a designer and builder of both plunger and centrifugal pumps and an interested observer of the development of the steam turbine, it does not appear that this prediction is likely to become true to any considerable extent.

Much attention has been paid to the development of centrifugal pumps during the past ten years, though the improvements made have not involved any new principle but have practically resulted in bringing the efficiency of the pump under high heads up to that formerly obtained only under low heads.

This result has been accomplished principally by the use of compound or multi-stage pumps and more careful design and construction aimed to reduce friction, have also been important factors.

The fact remains, however, that the centrifugal pump is relatively an inefficient machine, for while efficiencies of over 80% are talked of, the makers seldom if ever guarantee over 70%, and when the losses of the motor (be it steam or electric) are taken into account the net efficiency will be about 60%, and Prof. A. Rateau, the well-known steam turbine inventor, in his paper recently read before the American Society of Mechanical Engineers, gives the mechanical efficiency of a number of turbo-centrifugal pumps at from 32 to 46%.

When the above efficiencies are compared with the 90% to 95% readily obtained by the best plunger pumping engines it will be seen that the centrifugal requires at least 50% more power (and fuel) to operate it than does the plunger machine.

A case in point is at Providence, R. I., where bids were recently invited for a 25,000,000 gallon pumping engine turbine driven centrifugals.

The contract was awarded for a triple expansion plunger pump at $95,000, although the turbo-centrifugals were offered at $73,000—the annual cost of operation, including coal, interest, depreciation and repairs, being for the plunger pumps $29,000 and for the centrifugals $45,000.

Prof. Rateau, in the paper previously mentioned, gives the following figures as indicating what could be expected of an ideal turbo-centrifugal water works pump:

Delivery in gallons per minute.........	5,200
Height to which the water is raised.....	460 feet.
Actual horsepower in water raised.....	730 brake H. P.
Combined efficiency, including condenser.........................	46 per cent.
Pressure of steam in pounds per square inch............................	210
Vacuum at the exhaust...............	28 inches.
Super-heat in the steam..............	100 degrees.
Consumption of steam per brake horsepower in water raised............	15 pounds.

It will be seen that with steam at the unusual pressure of 210 pounds and in addition super-heated 100° the steam consumption is 15 pounds per pump horsepower. Prof. Rateau's statement that "It will be observed that the system described is quite as efficient as the best piston pumps now employed," can hardly be accepted as true of American practice, for as compared with these figures there are several plunger pumps in operation to-day which, though working with much lower steam pressures and without super-heat, require only 11 to 12 pounds of steam per pump horsepower or 25% less than the turbo-centrifugal —and it is safe to say that with the same steam pressure and super-heat as given for the turbo-machine the plunger pump would exceed its economy at least 50%.

The centrifugal pump is particularly adapted to the handling of sewage or water containing a large amount of "trash" such as would choke the valves of an ordinary pump and (when fuel is cheap) may also be advantageously employed where a large quantity of clean water is to be raised to a moderate height, but when fuel is at all an item it is usually more economical to install plunger pumps if the head is over 30 or 40 feet, and the service at all continuous, as, for instance, at Chestnut Hill, Boston.

There are also many locations where pumps are required for only occasional service or where special conditions prevail for which centrifugal pumps can be used to advantage.

In brief, the field of the centrifugal pump is in handling large quantities of water under low heads and it can only be considered for the higher heads when conditions are such that its convenience in operation will offset its lack of economy.

The centrifugal pump has a large and rapidly widening field, but until it is improved so as to remove its present handicap of 30 to 50% inferior economy it can hardly be expected to displace the plunger pump for ordinary water works service.

PRESIDENT SHERRERD: The next paper on the programme, "The Meter System in Cleveland, Ohio," will be presented by Prof. Edward W. Bemis, Superintendent Water Works, Cleveland, Ohio.

MR. BEMIS: I am not going to inflict upon you the reading of this paper, which is all in print. Doubtless many of you have looked it over. I will simply call attention to a few points in it, and give some additional data.

We attempted in Cleveland two years ago to set meters in a municipal plant in a large city more rapidly than, I think, it has ever been attempted before. There are two cities, New York and Milwaukee, that have more meters to-day, but in proportion to the size of the city we are way ahead of New York, which has attempted very little metering of small consumers. We differ from Milwaukee in the fact that although we have not as yet metered as many consumers—we have about 25,000 meters, and they have about 35,000 in a city somewhat smaller—nevertheless we have enjoyed the right to set meters at the expense of the department wherever we pleased, while in Milwaukee the meters have been set at the expense of the consumer and only where the consumer desired, in most cases, except in large business properties. We, therefore, have had the opportunity of setting them with all classes of consumers, who might not, under the Milwaukee plan, have desired to purchase meters. There was a very good reason for our entering on this policy at the beginning of 1902, for we then faced the fact that the supply of water from our old in-take was bad, and that it would be three or four years before we could have enough water from the new in-take, even by the introduction of very expensive additional machinery, in order to supply the entire city with pure water, if the consumpion increased as it had been increasing during the previous twenty years. We also did not wish to determine how to increase this supply for a year or two until we could make further tests of the purity of the water in Lake Erie. We must restrict our consumption until we could decide what ought to be done for a period of years in the future. We had before us the encouraging example of Milwaukee. In the opening of my paper I have presented what seems to me a very interesting contrast. In 1877 Milwaukee was using 113 gallons per capita. She had reduced it so that in 1902 it was 81; the year before it was 80. We had in 1887 a consumption per capita less than that of Milwaukee. We had less than 100 gallons—96 gallons—while she had 113. Yet, in 1901, before we began the introduction of meters, our consumption had grown from 96 to 169 gallons per capita, while that of Milwaukee had fallen from 113 to 80. The key to the problem was that Milwaukee had set an enormous number of meters, while Cleveland, during the fourteen years, had set very few. We realized that there were two great difficulties confronting the rapid setting of meters. One was the possible effect on our revenue, and the other the possible unpopularity with the mass of voters and consumers. We tried to meet both of those difficulties. We tried to meet the first by adopting a peculiar system of minimum rates instead of having a rate based solely upon the water used. If the assessment rate was $4 or less per year, then, under the minimum, it would be still $2.50 a year. If the assessment rate was $7 or less per year, then we established another minimum of $4, which must be paid whether that amount of water was used or not—payable $2 semi-annually. If the assessment rate was $10 or less, the minimum was $6. On larger assessment rates where a ⅝″ meter was installed, there was a minimum of $8 a year; and on all larger meters a minimum of $10 a year. That was very successful in preventing any considerable loss of revenue from the meter system; while the growth of the city, which was very rapid from 1901 to the end of 1903, further came to our relief. However, there has grown up the feeling in the city that these minimum rates have now served their purpose, because it is thought that the revenue of the Water Works Company now will stand a repeal of the minimum rates, and it being a city plant with a bonded debt of only 40% of its structural value, there is no necessity of earning a profit, as there would be in a private plant. We do, however, pay interest out of the water works' revenue on our bonds, and a good share of the expenses of construction from year to year; and we furnish water free for all public uses. There is now a bill in the council which is quite likely to pass, repealing all the minimum rates with the exception of the lowest of $2.50 a year, $1.25 every six months. That will, perhaps, be retained to meet the objections of physicians and others that it is necessary to take away the temptation from some landlords and some people to use too little water for health; and $2.50 a year, at our rates, which are very low, will allow an ample supply of water for all necessary purposes for a small family. There is a further reason for leaving that minimum, since $2.50 a year is about our estimate, or a little bit larger than our estimate of the repairs, interest, meter depreciation, and the operating expenses of reading the meters, and clerical work at the office necessary in connection with them. That will probably fall to about $2 a year, or somewhere between that and $2.50. The cost on the large meters is very much more than this, and it is, therefore, reasonable to allow the $10 minimum to remain on those, which will a little more than cover (according to our calculation) the cost of maintaining them.

I said we had two difficulties to meet. The financial difficulty was one. We are able to say, what I did not state in my paper, that we have lately reduced the operating expenses very largely. If the pumpage had increased during the last three years as it has been increasing every three years since 1880, or even earlier, our pumping expenses this year, even at the pumping station, would have been $50,000 a year more than they are, even at the low rate of $4.68 per 1,000,000 gallons of water pumped, which was our cost last year at the pumping station; and that is a very low figure. It is only two and one-sixth cents for every million gallons raised one foot. We have, however, an expense to set against this on account of meters for all these small meters. We now have about 20,000 ⅝″ meters, as compared with less than 200 two and a half years ago, at a cost of about $34,000 a year thus far additional, leaving a net profit of about $16,000. In addition to that there is a saving of the enormous cost of construction, which I have worked out with some detail, but will not bother you with here.

I think the greatest defense of the meter system is the saving in the cost of extensions which would be otherwise necessary.

We have had to meet another difficulty in the introduction of the meter system on any rapid scale, and that is its unpopularity among some consumers. We find that about 92 out of 100 gain financially by meters. We charge nothing for faucets, nothing for small lawns of less than 66 feet frontage. We charge $2 for every bathtub, $2 for every water closet, $1 a room for the first three rooms, and $3 is the minimum for a house a year, and 50 cents for every additional room. An eight room house, with one closet and one bath tub, would be charged $4 for those two fixtures, $3 for the first three rooms, making $7, and $2.50 for the other five rooms, or a total of $9.50. That is comparatively a low rate. And with all these minimums there has been a saving to every nine out of ten who have meters. Nevertheless, there is more kicking, naturally, on the part of the other one-tenth, as the kickers will always make more noise, although they are a small minority than the others will make of applause; and, of course, even many of those who are saving from the use of meters have been at some expense to improve their plumbing, and some of them would probably be glad to have the meters taken out.

We have had to contend with another difficulty, and that is the fact that from the very start the mayor and the executive department of the city were more enthusiastic, and have continued to be more enthusiastic, for the meters than the city council which controls the appropriations for them. The reason for that is not by any means due to the meter question itself, but to certain political conditions in Cleveland which I will not undertake to enter upon here. The opposition selected the meter as one of their points of attack. Although the press has sustained us very largely—in fact, I might say there has been no opposition as far as I can determine, but on the contrary very vigorous editorials in support from leading papers, and although the majority of consumers seem very much pleased and we are receiving applications for meters at the rate of about 250 a month now, yet there has been a disposition to oppose our compulsory setting where the meters were not desired. Still the council feel they could not stand in the way of our setting meters where there is evidence of waste. So they have just passed an ordinance this week over the mayor's veto which practically restricts our setting of meters on residences except where we have reason to believe there is waste. The law department has ruled that the council had no legal right to take this action. I do not know what the result will be on the further extension of meters, but since we still have a right to set meters on those services where we have any evidence of waste, we have still a large latitude. We have now metered 42½% of the services, and we have just received from the council an appropriation to buy enough large meters to set every unmetered service over ⅝″ remaining.

Mr. Brackett has lately published in the proceedings of the New England Water Works Association data which show that less than 7 gallons of water is used per pupil in the schools of Boston and Eastern Massachusetts based upon the average attendance during the school days, omitting vacations, Saturdays and Sundays. We find that the 15,000 pupils in the parochial schools of Cleveland, which have been metered several years, are using only 5 gallons per capita of average daily school attendance. Of the first five of the schools that we metered during the month of May, we found that three of them were using an average of 5 gallons per school day per capita, one was using 29 gallons, and one was using 543 gallons per day per capita.

We have now metered every business place where the connection is larger than one and one-half inches, and there are only 134 business places where the services are larger than ⅝″ that are not metered. There are only 331 unmetered free connections. We have authority to charge for all water beyond a reasonable amount per capita in all the schools. We have fixed upon 10 gallons per capita for schools, 40 gallons for charities, and 150 gallons for hospitals. There was some doubt as to whether, under the Ohio law, we could charge for the ordinary use of the schools. That point is still under discussion. I have just completed, since this paper was printed, an investigation of the results of our meters additional to what I give there. We have reduced our per capita consumption from 169 to 142 gallons. This year it will be less than that. Some further investigations have been made along the lines followed in Providence and Milwaukee several years ago, with reference to the water used through our meters. Of the 25,000 meters I have first taken those that were used for business purposes, and find that about two-thirds of all the water metered is used in about 3,000 meters. Then I have substracted the other meters which have not been in long enough to show us anything definite, and that left 16,820 meters that have been in use more than a year. Of the 16,820 house meters that have been in use about a year or more one-third, or 5,770 meters, show an average use for six months of only 1,378 feet. and 5,550 others show a use of only 3,767 feet. The average of the 16,820 was 7,000. In other words, about one-third of the meters show a use of only 56 gallons per day, and as there are on an average seven persons to a connection in Cleveland, this would make about 8 gallons per day per capita use for about one-third of those houses metered for about a year; another one-third used 155 gallons per day, which divided by 7 would give about 23 gallons per capita. But the average of the whole is about 300 gallons per connection, or perhaps 43 gallons per capita.

Then I went a step further. To illustrate the absolute justice of the meter system, I took in the first place the amount of water used by this one-third that used the least, and I find that even at our low rate of 40 cents a thousand feet, and with our low rate of assessment which I have just explained to you, and which ignores faucets, lawns of less than 66 feet front, and only charges $2 for a bathtub, $2 for a closet, and 50 cents for every room over the first three, that nevertheless one-third of our metered consumers that were the most economical would have paid last year, if on the assessment basis, not 40 cents a thousand feet but $2.74 for the water they actually used. The next one-third of our consumers would have paid $1.40. The next group of consumers, of about one-sixth, would have paid 88 cents. Another group, 55 cents. Another group, 33 cents, and another group, 15 cents. Those that were using the most water were getting it at the rate of 15 cents a thousand feet, while those who were most economical were paying $2.74 a thousand feet. If we abolish our minimums, except the lowest, as we are planning to do, then the consumer who is economical will get the advantage of it, as he has in large measure, even under our minimum. The present average meter bill in the 20,000 metered homes has been 25% below the old assessment rate. With the abolition of the minimum our metered residences will pay only about 33% of the old assessment rate; and the families that are more economical will be paying only 50 or 60 cents a year.

I have again attempted to apply the rate of use of the houses that are metered to the houses that are not metered. This is fair because the houses that are not metered are on the average assessed only 75% as much as the average house assessment for those that are. Probably they do not use legitimately any more water per house. Cleveland is using more water than many cities because there is no source of supply outside of the water department except for a very few factories that are contented with muddy water from the river, or from that portion of the lake nearest the shore. It is too expensive for them to go out very far. So that nearly all the factories use city water, and their use alone with that of the largest buildings is about 35 gallons per capita, which is at least as large as in many cities. Of course Cleveland is a large manufacturing city. Add this to the legitimate use of all the rest of the city on the basis of the houses that are metered, and we would have a use of 74 gallons per day per capita, which, however, is only 54% of what we are to-day pumping. Two-thirds of the houses are not yet metered. We must, of course, allow for the slip of the pumps, which we have measured very carefully with Coles' pitometer. We find that with the pumps we are now using the slip is less than 5%, which would represent 7.1 gallons per capita per day. The public and free use we do not yet know. Some of it would always have to be guessed at—in case of fires and other purposes, although the fire use could be pretty carefully approximated by the records; but the valuable paper of Mr. Dexter Brackett affords some light on this head. If we allow 7.11 gallons per day for free use, and the same amount for slips of the pumps, that would only bring our consumption up to about 88 gallons per day per capita. Then there is the waste in the pipes. We do not believe there is very much waste in our mains, which are not as old as in many cities. We have not been bothered much by electrolysis as in some cities, although we have some trouble. I notice in Mr. Brackett's report that he estimates that there is a probable leakage per day per mile of pipe in most cities of from 10,000 to 15,000 gallons. Of course there are exceptions either way. If we allow 10,000 gallons per day per mile, which is all we need to allow for the Cleveland system, I am sure, for each of its 594 miles of pipe, that would bring the whole legitimate consumption up to only 102 gallons. Our pumpage last year was 142 gallons, so that there are 40 gallons, or about 26%, of our pumpage that we could stop by further metering, and perhaps by the discovery of leaks in our mains that we do not know of, or possibly by discovery of the stealing of water from fire services, etc., if there be such theft. The meter system seems to me very popular with 90% of the users. I do not think that the recent refusal to allow us to continue compulsory metering is going to be very effective, in view of the provision that we can keep on setting meters wherever we have evidence of waste.

We have been probably somewhat handicapped in our introduction of meters in Cleveland by an ordinance that has been in operation over ten years, that all water that passes through a meter shall be paid for, whether used or not. That is a somewhat common provision with water works plants. It may be an absolutely wise one. We have not attempted to change it in Cleveland; yet it has undoubtedly caused a great deal of friction in two classes of cases: one, where a leak develops under ground, unknown to the owner or tenant, or to the water works, and cannot be known provided the leak is not so great as to cut off the pressure, which it often is not. I understand since I have come here that there are some cities that give their board of water commissioners, or superintendent, discretion in that matter under those circumstances. Second, there is another class of cases where that rule has caused considerable friction, in which waste occurs from leaking water closets, no notice of that waste reaching the landlord. In such cases we try to notify the owner as well as the tenant. I notice that some cities are not charging for such waste until after notification has reached the owner or his authorized agent. Whether that course is wise or not is another matter which I think we can very profitably discuss. It has a very important bearing on the popularity of meters. I think above all things that we should make meters popular, and this will be accomplished if we can only get the opportunity to set them.*

We have done one thing in the line of making meters popular, which I am convinced was wise. We did not confine our meter setting during the first year to the districts which we believed were wasting most water, but we selected districts of all types, and I think there were rather more installed in classes of property where there was not much waste than in other classes. The second year we proceeded perhaps a little more in the waste district, but still set a great many in other districts. The greatest waste from house consumers is in the older classes of property, as you are aware, and not so much in the newer sections of the city.

Many of our service pipes were laid before the passage of the present ordinance which requires them to be 5½ feet below the surface. Many service pipes are only buried 4 feet. The frost went down last winter 6½ feet. Suppose a service pipe should freeze because it was above the frost line, how far, if at all, will the freezing extend to portions of the pipe below the frost line? On this subject your experience will be very helpful. There may be some questions which Capt. Beardsley, who has direct charge of our meter department, and who is present, can, no doubt, answer satisfactorily.

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*Since reading this paper discretion in reducing bills in such cases has been lodged in the superintendent.

THE METER SYSTEM IN CLEVELAND.

EDWARD W. BEMIS.

SUPT. WATER WORKS, CLEVELAND, OHIO.

No city has ever set so many meters in so short a time as has Cleveland during the past two years. The number in use increased 21,686 during 1902 and 1903, 96 per cent. of which increase was in $\frac{5}{8}$-inch meters. There were only 121 of these in use during December, 1901, but in December, 1903, there were 20,850. It was high time two years ago for this attempt to do what should have been done long before. A comparison between Cleveland and Milwaukee illustrates, with remarkable clearness, the results of metering.

The population of Milwaukee had grown from 177,000 in 1887 to 300,000 in 1901, or 70 per cent., while that of Cleveland had grown with but slightly greater rapidity, having only increased 77 per cent., or from 232,000 to 411.000 in the same fourteen years. The number of connections in use had increased more rapidly in Milwaukee than in Cleveland. In the former city it had grown from 13.243 to 43.386, or 238 per cent., while in Cleveland it had only grown from 22,655 to 55,130, or 142 per cent. The number of meters, however, had increased in Milwaukee eighteen-fold, or from 1,729 to 31,114, while in Cleveland the number had increased only twofold, or from 1,525 to 3,344. Behold the results in pumpage:

The daily pumpage in Milwaukee increased only from 20.000.000 gallons in 1887 to 24.000,000 gallons in 1901, or 20 per cent., while in Cleveland it increased from 22,000.000 to 69.000.000 gallons, or 213 per cent. in the same period. The daily consumption per capita declined in Milwaukee from 113 gallons in 1887 to 80 gallons in 1901, but in Cleveland it rose from 96 gallons to 169 gallons in the same time. In other words, the consumption of water in Cleveland, which was nearly one-third less per day per capita in 1887, was over twice as much in 1901 as in Milwaukee.

On assuming the superintendency of the Water Department in September, 1901, the writer of this paper began, with the able co-operation of Mayor Johnson, a campaign of universal metering. In January of the present year 25,030 meters were in use on 42.5 per cent. of the 58,852 services. The average daily consumption in 1903, was 62,010,650 gallons, or 7.5 per cent. less than in 1901. It was 142 gallons per capita instead of 169 gallons. If the remainder of the city is metered and a careful examination is made of the possible leakage in street mains, the consumption ought to be reduced to 100 gallons. It cannot be made so low as in many cities because of there being no source of water supply except to a few factories, aside from the City Water Works, and because about 40 gallons per day per capita are used for business purposes and in large hotels.

The average increase of water used every three years from 1882 to 1900 had been 32.9 per cent., and during the three years ending in 1900 it had beeen 38.7 per cent. Since the city was growing rapidly and was very prosperous during the following three years, it is reasonable to suppose that the consumption, without house meters would have increased another 32.9 per cent., and would have averaged about 80,000,000 gallons per day last year, or 37,000,000 gallons—i. e., 43 per cent. more than was actually pumped. The pumpage the first four months of the current year has been slightly less than for the corresponding period of 1900, while the average increase for the four years in this city since 1880 has been 46 per cent., and during the period 1896 to 1900 it was 47 per cent. This does not take into account the slip of the pumps, which has been carefully measured by Mr. Cole with his Pitometer, although only approximate results can be reached. It appears, however, that owing to the use of newer and more improved pumps the slip in 1900 was about 10 per cent. and in 1903 about 5 per cent.

In order to popularize the meters they were set impartially on every street radiating from certain centers selected as representative of different classes of the population. It was thus possible for the more prudent housekeepers to realize the advantage of the meter, and to create public sentiment that should meet the opposition of the more wasteful. Neither the flat nor the meter rates, however, were changed. The flat rate is $3 for the first three rooms or less, and 50 cents for each additional room, together with $2 for every bath tub and every water closet. On all flat rate bills of $1.50 for six months there is a discount of 15 per cent. Nothing is charged for lawns unless where there is over 66 feet frontage. Thus an eight-room house with one bath and closet would be charged $9.50 per year. The meter rate is 5 1-3 cents per thousand gallons, or 40 cents per thousand feet for all consumers, large or small.

Of the thirty-eight cities of the United States of over 100,000 population, only two, Philadelphia and Washington, charge less on the meter basis than do we for ordinary house consumers, and both of these cities pay a considerable revenue to the Water Departments for water used for city purposes, while the Cleveland Water Department does not receive a cent, although it furnishes a large amount free for public use. Five other cities of the 38, viz., Chicago, Toledo, Detroit, Indianapolis and Buffalo, have a lower rate for large consumers. But the scale is so adjusted that in most of these places any Cleveland firm would pay higher rates than it now does with us. In the two most marked exceptions, Detroit and Buffalo, the city pays the water department a large sum annually for water used, which is also true in the case of Indianapolis.

Until last November few objections were heard to the rapid increase of meters in Cleveland. Three causes have since somewhat changed this condition:

1. Some political conditions not at all connected with meters, but which have led to an opposition in the Council to administration measures.

2. An epidemic of typhoid fever, due in very large part to the lake water, visited the city in the early part of this winter. As this was unfortunately coincident with the discussion of the meter question, the amusing idea arose, and was for a short time widely held, that the meters were the cause of the typhoid. Fortunately the introduction in March of a new water supply through a tunnel running four miles out into the lake has already almost entirely stopped the typhoid and the scare connected therewith, but those desirous of prejudicing the people against the meters have introduced the matter of health in a new form by claiming that the screen embedded in our meter, the Trident, collects organic sediment and especially small fish and allows them to putrify and injure the water. Investigation has shown that no animal matter is to be found on these screens, except that on less than one meter out of a hundred a small fish may lodge in the course of a year. Usually, however, this lessens the flow of water, and the Water Department is notified and removes the fish. To avoid this difficulty in the future, screens are being placed at the outlets of the tunnel and of the reservoirs with a ⅛-inch mesh, which will probably prevent all such trouble hereafter. The experience of other cities is solicited as to how fine a mesh it is practicable to use.

It is well known among Water Works Superintendents that there is scarcely a committee of experts that has ever reported on water purification that has not suggested meters in order to lessen the cost of a purer supply. It is obvious that this would not be done if these experts, from Maine to California, had any evidence of the unsanitary character of meters.

FREEZING OF METERS.

A third cause of objection to meters this year has been the freezing of many meters and metered services. This condition has not been peculiar to Cleveland. From water works superintendents all over the North have come reports of similar conditions. The Weather Bureau records show this to have been the coldest winter since the establishment of the Signal Service. The effect of this on the Water Department was greatly aggravated by the almost entire absence of snow since the thaw in January, which left the ground exposed to the cold. During the last few years our tappers have been instructed to refuse to tap the street mains for new services until the trench from the main to the curb was 5½ feet deep, but a large proportion of the old services of the city were originally laid only four feet deep, or have become only that deep on account of the grading down of the street along the line of the service pipes. No special trouble, however, had occurred from freezing prior to the past winter, when the frost on some streets went down from 5 to 7 feet. Four causes then contributed to the large amount of trouble, as follows:

a. The condition of temperature and snow, above referred to.

b. The shallow service pipe setting, also referred to above, which not only existed in the streets but also inside the premises of the owner.

c. The knowledge of a meter being in place led many families to refrain from letting the water run night and day to prevent freezing, as had been customary where the danger from freezing was thought to be great. Our water rates are so low, being only one cent for 200 gallons, that I announced through the papers that one could permit one quart a minute to run constantly at an expense of only two cents a day, or $1 for the fifty days when the most of the freezing occurred, during January and February. Many misunderstood this, and allowed a large stream to run, and are now claiming that they should not be charged for it, as they did it by what they thought was the authority of the Department. Many others, however, did not let their water run constantly, and their service pipes were so poor that they froze in the unusual winter weather.

d. The meters themselves, in many cases, were not set properly in the sewer pipe setting, which was briefly explained to the American Water Works Association last year. The accompanying cut shows the ordinary setting as it was last year, save in the matter of the wooden cover, while the other drawing, marked "special setting," illustrates the extra foot of sewer pipe that we are now placing in more exposed locations. The meter hitherto, when placed outside and not in brick vaults, was enclosed in four feet of sewer pipe 15 inches in diameter on the inside. Risers came up from the service pipe to the meter, the top of which was only 18 inches from the iron cover. Resting on the top of the meter was a loose wooden cover. Within the entire four feet of sewer pipe there is no earth, but merely an air chamber.

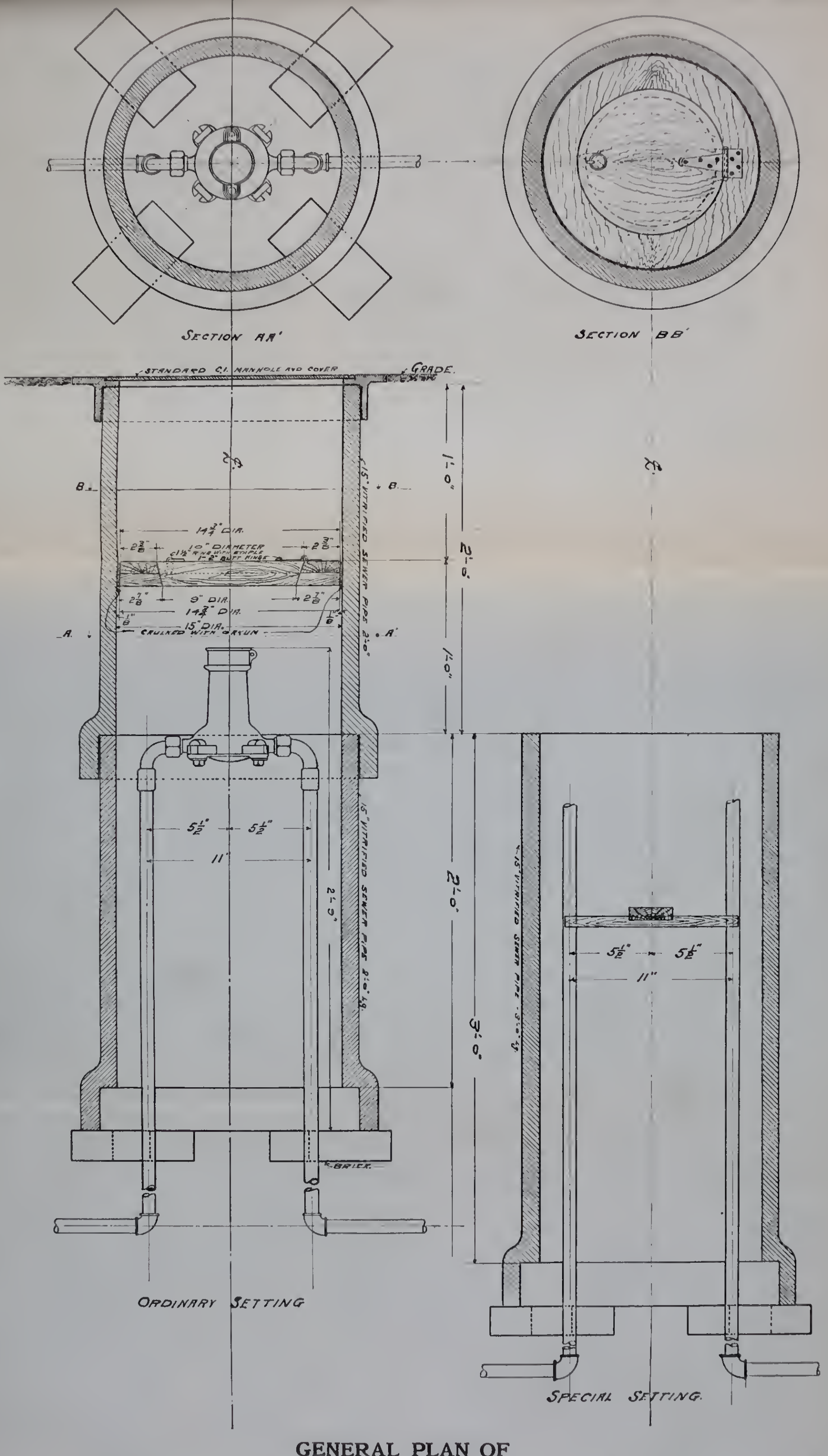
With 979 settings in such sewer pipe in the winter of 1902-3 not one froze, but during the past winter 1,226 out of 10,423 set in sewer pipe, or 11.7 per cent. froze, as compared with 136 out of 4,483, or 3 per cent. set in brick vaults and 165 out of 9,727, or 1.7 per cent. set in basements. To be sure, this is not a fair comparison, at least as between sewer pipe and basement settings, since meters were only set in basements where the latter were in good condition and gave promise of being free from frost. In the older sections of the city where the service pipes were near the surface, the sewer pipe settings were almost universal.

Unmetered services also froze in large numbers in the same sections of the city in which the metered services froze in largest numbers. Still, after all allowances are made, we believe that there were two defects in the sewer pipe setting which are now being remedied as fast as possible, as indicated in the accompanying cuts, as follows:

First, the wooden meter cover did not fit tightly enough; indeed, it often became tilted as it rested loosely upon the meter. We are now substituting throughout the city a wooden rim (diagram) tightly caulked by oakum against the sewer pipe (A), attached to the rim, which is about one inch thick, is a larger hinge, which is also attached to an inner wooden cover that comes down to the opening of the wooden rim on a bevel, and fits so tightly as to give promise of being almost air tight. This wood is being subjected to a chemical treatment that will preserve the wood. This wooden cover is only one foot below the iron cover, and cannot be left up against the sewer pipe or the iron cover, so that the meter reader will be obliged to put the wooden cover in proper position before leaving the premises. In some sections of the city where there is most danger of freezing an extra foot of sewer pipe is to be placed underneath the four feet that we now have, and a cross brace of wood is to be used partway down the riser to keep everything in place, as illustrated in the cuts.

The experience of other cities in the use of outside settings will be very helpful to us in Cleveland, and it is to be hoped that the discussion following this paper will bring out this information.

Of our meters and metered services, 60 per cent. more froze on the south side than on the north side of the streets running east and west, as was to be expected, but about the same number on each side of the streets running north and south. Of 2,904 services that froze—although in about one-half of the cases the meters did not freeze—40 per cent. were on the south side of the streets, 25 per cent. on the north side, 18 per cent. on the east side, and 17 per cent. on the west side.



GENERAL PLAN OF
ORDINARY AND SPECIAL SETTING OF WATER METERS
WATER WORKS, CLEVELAND, OHIO.

Proceedings American Water Works Association, 1904.

The thawing of services was mostly done by four electrical machines. Three of them obtained their current from the street railways, at a cost of 6 cents per kilowat, or $39.18 for the 434½ hours in which current was actually used. This current was of 300 amperes and 5 volts, or a total of 1.5 kilowats per hour. In cases where the wires, nearly 1,000 feet long, could not reach from the trolley to the meter we used a steam machine to furnish power to the dynamos. This machine of 12 H. P. had just been purchased for other uses of the Water Department and was easily transported on wheels. The total cost to the Department of repairing meters and thawing out the services has been $11,520, or about 46 cents per meter, if distributed equally over the 25,000 meters in place. Of this sum about $3,500 has been required for inspection, taking out frozen meters, or those where only the service was frozen, repairing the meters either in place or at the shop, and resetting them. The machines thawed out 1,164 metered services and 349 unmetered, or a total of 1,513, at a cost of about $7,700, or about $5 per service. Private plumbers thawed out a few metered services, and many more unmetered ones.

COST OF SETTING.

The following table will give the cost of labor and material in the three kinds of settings in 1903, and the estimated cost of the improved sewer pipe setting in 1904. The labor cost is high in basement settings, because the basement meters are widely scattered. In brick vaults the labor cost is low per meter because in such vaults two or more small meters are sometimes set in one vault. This table refers only to ⅝-inch meters:

COST OF BASEMENT SETTINGS.

Brick	.12
Cement	.05
Cover	.30
Fittings	.25
Total material	.72
Labor	$3.23
Total	$3.95

BRICK VAULTS.

350 brick	$2.45
1½ sacks cement	.38
2 couplings	.08
2 ells	.12
1 nipple	.06
1 Union	.24
1 ring and cover	3.21
Total material	6.54
Labor	2.92
Total	$9.46

SEWER PIPE SETTINGS.

	1903.	*Estimated cost 1904.*
Sewer pipe	$1.46	$1.84
Frost cover	.18	.47
Cross brace	.00	.04
Ring and cover	1.42	1.42
2 ells	.12	.12
2 couplings	.08	.08
7′ of ¾″ pipe	.35	.35
Total material	$3.61	$4.32
Labor	4.01	4.51
Total	$7.62	$8.83

The average cost of setting 13,407 ⅝-inch meters set in 1903 was $6.87, and the meter itself, with connections, cost $6.50, or a total of $13.37. During that year 857 ⅝-inch meters were set in brick vaults, 3,174 in basements, and 9,378 in sewer pipe.

COST OF OPERATION.

The cost of operation of the meter department is greater in this period of rapid setting and growth than it will be later. Nearly all the expenses of investigation of where to set new meters, and the clerical work connected with the setting, changes in the form of setting, and experiments connected therewith, are charged to operation. Many more meter readers are now employed in proportion to the number of meters in place than will be needed later. It has thus far been customary to employ one meter reader for every 1,000 meters in place, and to have these men not only read the meters every six weeks from March 1 to December 1, but also to investigate all causes of waste and to notify the property owners and tenants of the same and direct them how to lessen the waste. It is also customary at every meter reading for a laborer to accompany the meter reader and to turn off the water in any house which is apparently wasting water, while the meter reader waits at the meter to detect any running water. We have hitherto bought none but Trident meters, of which we secured 10,000 ⅝-inch, 800 ¾-inch and 200 inch meters, previous to last year, and 15,000 ⅝-inch last year. In each case this company was the lowest bidder, and we have found the meters very satisfactory, but have thought it well to frequently test them, to make sure that they were running all right. As time goes on it will not be necessary to do this so often, or to read the meters so frequently.

Last year the meter reading and clerical work connected therewith amounted to $1.10 for each of the average number of meters in use during that year, while the repairs were 10 cents. Interest and depreciation at 8 per cent. would be $1.07, or a total of 2.27.

On these small meters the increase in cost of about $34.000.00 is more than counterbalanced by the difference of $50.000.00 between the pumpage expenses and what they would have been if the pumpage had increased as rapidly the past three years as it had been doing previous to the introduction of meters on a large scale. There remains from meters the large saving in the fact that the city has not been obliged to put in new pumps, buildings for the same, and large mains, which otherwise would have been necessary. Even if contracts for these had been let two years ago, they would not have been ready to enable the city to be supplied this spring with pure water from our new intake and therefore the typhoid fever epidemic would doubtless still have been at it height.

RESULTS TO THE CONSUMER.

It is too early in the history of the domestic meters in Cleveland to determine the results to the consumer. At the semi-annual collection last October only 8 per cent. of the entire number of houses metered paid more than under the assessment rate. Two-thirds of 1 per cent. paid the same, and the other 92 per cent. paid less. Twenty-four streets were selected with a good class of houses where nearly every home had been metered for over a year. On these streets having an average annual assessment of $11.83, the 825 families were paying under our system of minimum charges $7.36, or 62 per cent. of their old assessment rate, and they were using only $3.95 worth of water per year, or 33 per cent. of their old rate; that is, they were using on the average only 9,875 feet per family per year, or 202 gallons per day. On a class of houses considerably poorer on eight streets were 172 residences, the average assessment rate being $7.64 per year, and the payments under the present minimums are $5.38, or 70 per cent. of this, and they are using on the average only $2.61 worth of water, or 6,525 feet per year. This is equivalent to only 134 gallons per day per family.

Finally the 648 metered places on 23 still poorer streets have been investigated for the year ending April 1st. Their annual assessment averaged only $6.14. They are now paying $4.66, or 76 per cent. of the above, and are using an average of only $2.32 per year, or 5,800 feet. This is equivalent to only 120 gallons per day per family, or probably only 25 to 30 gallons per capita. The better class of houses would only pay 33 per cent. of the assessment rates if there were no minimum, the next poorer class of houses would pay 34 per cent., and the still poorer would pay 38 per cent.

USE BY SCHOOLS.

The use of water in the parochial schools, both Lutheran and Catholic, has been ascertained for they have been paying meter rates metered. It is proposed henceforth to allow free to those and to the public schools some limited amount of water per pupil per day of school attendance, and charge both public and private schools all in excess of this amount. During the approximately 144 days of actual sessions of the schools during the six months ending April 1, 1,753 pupils in average attendance on the five Lutheran schools used 3.5 gallons per day per pupil. Similarly the 14,130 children in average attendance in the thirty-four Catholic schools used 3.9 gallons. In each case, however, there were buildings where over three times this average amount was used, even though metered. In fact, there was one building that used eight times this average, while many others used far less than the above average of under four gallons per day.

MINIMUM RATES.

The minimums that were adopted with the beginning of universal metering in 1902 were as follows:

Five dollars semi-annually for all meters larger than ⅝ inch, unless meters had been put in by the consumer when the minimum was $4. In the case of the ⅝-inch meters there are four minimum rates; $1.25 every six months for all semi-annual assessment rates of $2 or less; $2 for those whose assessment rates are $3 or less; $3 for those whose assessment rates are $5 or less, and $4 for all others. There were two reasons for these minimum rates; one to prevent too great a reduction in revenue in a city which gives the small consumer the same low rates as are paid by the United States Steel Company with its water bill of $30,000 a year; the other reason was to meet the objection of those who feared that without a minimum people would economize unduly in the use of water. Even the lowest minimum at our rates allows the use of 130 gallons per day, or sufficient to flush a water closet 20 times a day, to flush 200 feet of ¾-inch pipe from the street main to the kitchen three times, and to allow 56 pint glasses per day for drinking, and 42 gallons for cleaning.

The time, however, has now arrived where the financial condition of the department permits the abolition of all the minimums, except the lowest of $1.25 every six months, which should be retained to insure a healthful use of water, and because it costs fully that amount to take care of the meter and to provide for interest and depreciation on it, even if not a drop of water goes through it.

An ordinance is now pending in the City Council to abolish all other minimums on the ⅝-inch meter.

EFFECT ON REVENUES.

Thanks to the growth of the city in business and population the reduction in charges to the residences that have received meters has been somewhat more than counterbalanced by the increased consumption of water by large business places and by the increased population. During the six months ending with September 30, 1900, the collections were $371,000. During the corresponding period this year they will be about $420,000, but if all the minimums, except the lowest are swept away, which would take effect with the October bills, the revenue during next winter will probably be about the same as four years before, while the majority of household consumers will pay only one-third as much as formerly.

The wages and salaries in the Meter Department are as follows:

A chief at	$2,000.00
A bookkeeper at	1,100.00
A few clerks at	660.00 to $900.00
Foreman and Inspectors at 30 to 42 cents per hour.	
Meter readers at	2.25 per day.
Installers at	2.20 per day.
Laborers at	1.68 per day.

Eight hours constitutes a day's labor.

CONCLUSION.

Despite the difficulties of the past winter the meter system is very popular with the mass of the people. During the first half of May preceding the time when this paper was sent to the printers, the requests for meters have averaged more than ten a day, Sundays included. Meters are set and cared for entirely at the expense of the Water Department. The early opposition of the plumbers to this work of direct city labor has practically disappeared. The Department is just undertaking a systematic lowering of all services throughout the city where they are not 5½ feet below the surface and located on streets where there is special danger of freezing. A few street mains are being lowered also, although none of them froze last winter. The press of the city is friendly, and the Mayor and Board of Public Service are very enthusiastic for the metering of every connection. It is probable that this year every connection larger than ⅝ inch and half of all the others will be metered. Only 465 services larger than ⅝-inch, including free connections, but not free lines, are still unmetered, and the Council has just authorized the purchase of $12,000 worth of large meters with which all of these services will be metered this year. If support is received from the Council all the remaining services will be metered within three years. What has been done already, however, renders it certain that even if the pace hereafter is slower, the time is not far distant when universal metering will be accomplished in this city of 450,000 inhabitants, which already has more meters than any other city in the United States, excepting New York and Milwaukee, and more meters on domestic consumers, probably, than even New York, although still a little behind Milwaukee in this respect.

METERS—THEIR USE AND BENEFITS.

PARK WOODWARD.

General Manager Atlanta, Ga., Water Works.

Much could be said in favor of the universal meter system for all water works plants. But having had a practical experience for the past 20 years in the use of meters here, I will confine myself to what they have done for Atlanta.

Prior to 1885 there were no meters in Atlanta. The rate charged for water was regulated by the number of outlets used by consumers.

The consumption of water became so great that it resulted in the necessity of adding to our pumping machinery in order to supply the demand for water and at the same time to give the necessary fire pressure. After a new pump was added and put in operation it was found that the force main leading from the pumping station to the city was too small for the demands made upon it. The loss by friction was enormous, resulting in a great strain upon the pumps and the pipe in the immediate neighborhood of the pumping station, and it was found impossible to give adequate fire pressure.

The only remedy left was to put in an additional and larger main. But the cost of putting in this main was only to be had by an extra rate of taxation being levied upon the people. This was extremely unpopular, and the idea was therefore abandoned, and an effort to arrive at some other remedy was considered. In the meanwhile the insurance companies complained of the insufficiency of fire pressure; and then it was determined to try the meter system. It was known that a large per cent. of the water pumped was allowed to run to waste; and to effectually stop this waste it would be necessary to make the consumer pay for it. So we adopted then the universal meter system.

Much complaint was made at the time, it being argued that it was unjust to require water consumers to pay for meters to measure the water they paid for. But the Board contended it was the only equitable way, for it was manifestly unfair to take the money from the general tax fund to put meters on consumers in about one-third the territory of the city where water mains were laid, and therefore require those who lived out of the reach of the water supply or fire protection to pay for meters used by those more fortunate in having the comfort and convenience of water supply and fire protection and decreased rate of insurance.

The introduction of meters saved money for the general taxpayers of this city, for without their use the rate of taxation would have been increased in order to raise a sufficient amount of money to pay for an additional main, more pumping machinery and larger reservoir and other necessary additions to the plant, estimated at that time to cost approximately $150,000 or more.

As an illustration of the result of the introduction of the meter system here, the pumpage for the month of November, 1884, when we had no meters, was 132,679,900 gallons, and the coal consumed was 575,000 pounds, being an average pumpage of 4,442,663 gallons per day and the consumption of 19,166 pounds of coal per day.

For the month of November, 1885, with the meters in service, the pumpage was 48,130,000 gallons, showing a decrease in pumpage of 84,549,900 gallons for the month. The coal consumed was 256,000 pounds, showing a reduction in the consumption of coal of 319,000 pounds for the month. The reduction in pumpage was 2,818,330 gallons per day, and in coal of 10,633 pounds per day. If meters had not been introduced our daily pumpage now would be about 25,000,000 gallons per day instead of 8,000,000 as it is, and the outlay necessary to put the plant in condition to meet the demands would have been over a million dollars more than has been spent on it.

One argument against the use of meters is that it reduces the income. This, of course, depends on what is charged. A minimum rate can be fixed and a maximum amount allowed for that rate. We charge here 80 cents per month for 6.000 gallons or less, and allow a discount of 25 per cent. on all bills paid on or before the 10th of the month following the month of consumption. And we charge 10 cents per 1.000 gallons net for all used over the 6,000 gallons.

The average domestic consumption here is 3.500 gallons per month. It must be borne in mind, however, that our accounts close each month, so that the minimum rate and maximum allowance commences with the first of each month. The revenue here under the meter system has grown from $32,000 in 1886, to $178,000 in 1903, and it will be over $200,000 in 1904. And in addition to this the city service, that is, fire, sewer, public buildings and grounds, etc., used in 1903 $160,000 worth of water, the same being charged for at the rate it would have been charged had the plant been owned by a private company. Of course, no money was paid for this service, but the Water Department took credit for it, as they were entitled to, so as to show the actual earnings of the plant.

Manufacturers are charged a scaling rate of 10 cents per 1,000 gallons net for 75,000 gallons, and scaled each 75,000 gallons ½ cent. per 1,000 gallons until it reaches 6 cents per 1,000 gallons. The scaling rate then stops, and all water consumed after 90,000 cubic feet is charged for at the rate of 6 cents per 1,000 gallons net. We have two pumping stations, and the estimated cost to deliver the water, counting operating expenses and interest on the bonded debt, last year was 5-7-10 cents per 1,000 gallons; so that manufacturers get water practically at cost over and above 90,000 cubic feet.

The appended table will give the result of water consumption, coal consumption and income since the adoption of the universal meter system. I also append, for comparison, a schedule of the flat rates in force before the adoption of the meter system.

Year.	Total No. Taps.	No. Taps Metered.	Gals. Water Pumped.	Pounds Coal Burned.	Income.
1883	1,663	95	859,448,080	4.701,700	$31,010.20
1884	1,832	570	1,148,420,700	5,624,400	35,763.95
1885	1,973	Genl. indn.	876,055,000	4,286,000	39,293.33
1886	2,077	1,372	574,925,000	3,008,300	32,745.48
1887	2,192	practically all			
1888	2,464	all	628,931,300	3,402,900	38,286.35
1889	2,883	all	756,762,600	4,070.320	56,369.50
1890	3,273	all	861,241,100	4,683,800	63,438.97
1891	3,759	all	942,966.730	5,097,900	74,431.90
1892	4.533	all	923,451,700	5,506,600	79,695.61
1893	4,934	all	1,296,550,800	8.348,000	81,822.71
1894	5.544	all	no data	5.459,100	65,452.61
1895	5,962	all	1,657,549,110	6,222,700	73,562.83
1896	6,496	all	1,814,963,500	5,647,900	83,339.39
1897	7,176	all	1,895,623,800	5,364,600	92,484.92
1898	7,974	all	1,807,661,800	5,095,100	103,774.54
1899	8,592	all	1,996,908,200	6,098.500	116,302.66
1900	9,277	all	2,146,635,700	6,741,300	133,819.26
1901	9,926	all	2,261,947.100	7,709,400	141,867.09
1902	10,676	all	2,511,687,200	7,884.900	157,041.03
1903	11,654	all	2,484,954,300	8,380.988	177.730.50

New plant put in operation in 1893. Old plant abandoned in 1904.

In 1904, meter rate reduced from 17 cents to 10 cents per 1,000 gallons.

You will notice that the income for the year 1885 was $39,293, that was under the old rate of 20 cents per 1,000 gallons; it being optional with consumers up to that time to take the flat rate or the meter rate, and for 1886, $32,745.48 (under the new rate of 17 cents per 1,000 gallons and all on meters), a falling off in receipts of $6,547.85. This shrinkage in receipts was more than compensated for in the amount of coal saved and water pumped.

In 1885 we pumped 876,055,000 gallons of water and burned 4,286,000 pounds of coal. In 1886 we pumped 574,925,000 gallons of water and burned 3,008,300 pounds of coal, making a difference in that year over the year previous of 301,130,300 gallons less of water pumped, and 1,277,700 pounds less of coal burned; this relative difference goes on "ad infinitum."

FLAT RATES.

	One Story.	Two Stories.	Three Stories	Four Stories	Five Stories.
14 feet and under..	$5.00	$7.00	$9.00	$11.00	$13.00
14 feet to 16 feet...	6.00	8.00	10.00	12.00	14.00
16 feet to 18 feet...	7.00	9.00	11.00	13.00	15.00
18 feet to 20 feet...	8.00	10.00	12.00	14.00	16.00
20 feet to 22½ feet	9.00	11.00	13.00	15.00	17.00
22½ feet to 25 feet.	10.00	12.00	14.00	16.00	18.00
25 feet to 27½ feet.	11.00	13.00	15.00	17.00	19.00
27½ feet to 30 feet.	12.00	14.00	16.00	18.00	20.00
30 feet to 32½ feet.	13.00	15.00	17.00	19.00	21.00
32½ feet to 35 feet.	14.00	16.00	18.00	20.00	22.00
35 feet to 37½ feet.	15.00	17.00	19.00	21.00	23.00
37½ feet to 40 feet.	16.00	18.00	20.00	22.00	24.00
40 feet to 45 feet..	18.00	20.00	22.00	24.00	26.00
45 feet to 50 feet...	20.00	22.00	24.00	26.00	28.00

NOTE.—All finished basements shall be taken as one story additional.

The family occupying the dwelling house to number not more than ten (10) persons, and for each person beyond that number 50 cents per year shall be charged. Dwelling houses occupied by more than one family shall be charged as follows: viz:

The second family, one-third (1-3) of the regular rates.

The third family, one-fourth (¼) of the regular rates.

The fourth family, one-eighth (⅛) of the regular rates.

Each family over four families, one-eighth the regular rates.

Or extra families shall be charged such rates as may be determined upon in the discretion of the Board.

And the Board do further establish that the extra and miscellaneous rates shall be as follows:

Stores and places of business occupied by one party when not over twenty-five (25) feet front, $6 per annum. For each additional ten (10) feet or part thereof, $3 per annum. Stores when occupied by more than ane party will pay dwelling house rates.

Bakeries that average a barrel of flour per day, $3.50 per annum.

Offices of professional persons, from $3 to $5 per annum.

Saloons, in addition to frontage, $6 to $100 per annum.

Hotels, in addition to the regular rates, for frontage will be assessed for each room, $1 per annum.

Taverns and boarding houses, in addition to regular rates for private families, for each room $1 per annum.

	Per annum.
Bathing tubs	$3.00
(Private dwelling of one family) 2d tub	2.00
(Private dwelling), over two, each	1.00
(Public), each	6.00
Water closets	3.00
(Private dwelling, one family), 2d closet	2.00
(Private dwelling), over two, each	1.00
(Hotels, taverns, boarding houses, places of amusement and blocks)	6.00
((Public)	6.00
Urinals, first	3.00
(Private dwellings of one family), 2d each at	2.00

	Per annum.
(Private dwelling over two each)	1.00
(Hotels, taverns, boarding houses, places of amusement and blocks, each	3.75
Building purposes for each 1,000 brick or perch of stone used	.05
For each 100 sq. yds. plastering	.14
Steam engines, each horse power, 10 hrs. per day	5.00
Printing offices, according to the number of persons, not including steam engines, from	$6.00 to 40.00
Printing offices, first power press	6.00
Balance press	4.00
Hand press	2.00
Private stables, for each horse up to two	2.00
Additional horse over two	1.50
Livery stables (including washing of carriages), each horse	2.00
Dray and team horses	1.00
Street sprinklers, for each tub per month	25.00
Brewers, for each 1,000 gallons taken	.20
Distillers, for each 1,000 gallons taken	.20
Railroad depots, each locomotive (trip out) from	75.00 to 100.00
Gas works, from	100.00 to 300.00
Fountains, one-sixteenth of an inch jet, in use four months in year, average use three to four hours per day	15.00
Fountains, one-eighth jet, in use four months in the year, average use three to four hours per day	60.00
Vegetable fountains, each	3.00
Use of hose, four hours per day in summer	3.00
Work shops for four persons or under	3.00
Manufacturer's frontage	6.00
Each additional person over ten	.25

All manufacturing and other business requiring a large supply of water are to be charged therefor per 100 gallons at the average estimated quantity during the year. The year to be estimated 300 days as follows:

When the quantity used average from 200 to 300 gallons per day, at the rate of 4 cents per 100 gallons.

When the quantity used averages from 300 to 1,000 gallons per day, at the rate of 3½ cents per 100 gallons.

When the quantity averages from 1,000 to 5,000 gallons per day, at the rate of 3 cents per 100 gallons.

When the quantity averages from 5,000 to 10,000 gallons per day, at the rate of 2 cents per 100 gallons.

When the quantity used exceeds 10,000 gallons per day, the price will in no case be less than 1 cent per 100 gallons.

METER RATES.

Meter rates must be paid monthly, at the rates of 20 cents per thousand gallons.

	Per annum.
Guano works (assessed).	
Ice manufactory (assessed).	
Elevators, per 1,000 gallons	.20
Cow	$1.00
Dyeing and scouring, from	25.00 to 100.00
Filling cistern, from	5.00 to 20.00
Hat manufactory, from	30.00 to 100.00
Ice cream saloon, from	15.00 to 20.00
Laboratory, per 1,000 gallons	.20
Oyster saloon, from	15.00 to 30.00
Packing house, per 1,000 gallons	.20
Photograph gallery, from	20.00 to 40.00
Ale or porter cellar, from	40.00 to 50.00
Rectifying whiskey, per barrel	.03
Soda or mineral water manufacturing, per 1,000 gallons	.20
Starch manufactory, per 1,000 gallons	.20
Stock yards, per 1,000 gallons	.20
Sugar refinery, per 1,000 gallons	.20
Tannery, per 1,000 gallons	.20
Vinegar manufactory, per 1,000 gallons	.20
Washing bottles, from	5.00 to 20.00
Washing barrels, per barrel	.05
Washing meats, per 1,000 gallons	.20
Wine cellars, from	20.00 to 50.00

	Per annum.
Barber shops, one chair	5.00
Each additional chair	3.00
Blacksmith shops, one furnace	3.50
Each additional furnace	1.75
Tailor shops, for ten hands or under	3.00
Each additional hand	.30
Shoe shop, for ten hands or under	3.00
For each additional hand	.30
Wholesale clothing, ten hands or under	3.00
Each additional hand	.30
Boot and shoe factory, for ten hands or under	3.00
For each additional hand	.30
Renovating establishments (assessed).	
Soap factory, per 1,000 gallons	.20
Paper mills, per 1,000 gallons	.20
Woolen mills, per 1,000 gallons	.20
Eating houses, from	10.00 to 30.00
Billiard saloon, per table	3.00
Slaughter houses, per 1,000 gallons	.20
Stone yards, same as work shops.	
Theaters, concert halls and other places of amusement (to be assessed).	
Banks, from	6.00 to 12.00
Steam apparatus for warming public halls, theaters, and other buildings (to be assessed).	
Book bindery, not less than	10.00
Candy factory, from	15.00 to 75.00
Cigar factory, per hand	2.00
Club room, from	15.00 to 75.00
Confectionery, from	15.00 to 75.00
Laundry (to be assessed).	

VICE-PRESIDENT ROWE: As you all know, the meter is the coming way of selling water. This subject is very interesting to me. We now have in our city 10,000 meters. I would like to have any point raised by Prof. Bemis here discussed thoroughly. We are open now for remarks.

MR. ALVORD: I have been very much interested in the remarks of Mr. Bemis. Before asking one question which I have in mind I should like to explain that I have had for some time a doubt in my mind as to whether the introduction of a universal meter system would always prove to be the economy which it seems to be on its face. There is no doubt, of course, as to the immense benefit in reducing the possibilities of future construction by the introduction of a meter system. I think we all recognize that. But there is the other question, is the operating expense of a universal meter system greater, or less, than the amount of additional pumpage necessary to support waste as we ordinarily find it when the water supply is pure and abundant? I have had occasion in two instances—one particularly interesting—to observe carefully the financial history of the introduction of a universal meter system, and it is observable in that case of which I have full data, that although the water consumption was greatly cut down by the universal introduction of meters, that the operating expenses of a universal meter system fully offsets the gain through the reduction in pumpage. This was very clearly brought out by a diagram which I worked out showing the rise in operating expense and the fall in consumption; therefore, I am particularly interested in that portion of Prof. Bemis' remarks in which he spoke of the cost of operating. I would like to ask if the professor thinks that his meters have been in long enough to accurately forecast what the operating expenses of such a system will be? That is to say, we all recognize that when new the operating expense of a meter system will be light, I think, but as the meters grow old and have to be repaired and tested, and a sufficient corps of men have to be constantly engaged in this line of work the operating expenses arrive at their normal condition, and my thought is, have we such data yet in connection with the very interesting experiment at Cleveland?

Professor Bemis: I would say that certain operating expenses will increase, such as repairs; but I cannot believe from an experience such as we have had that the meter expense will increase as fast as certain other operating expenses will diminish. We have charged to operating expense all the cost of an unusual number of meter readers and a corps of investigators which are incidental to a first installation, but not necessary afterwards. We thought it wise, in order to popularize meters, to follow up every case of waste at first, informing people of it promptly; so we have read meters oftener than we will read them hereafter. We are already beginning to reduce the frequnecy of reading in certain districts of the city. At first we undertook to read meters every six weeks, although we only collected bills twice a year. We also undertook to inform everybody of any considerable waste; and we still will do that; but the number is diminishing in proportion to the number of meters. In considering the relative increase in operating expense I think you should take into the calculation what your operating expense would be without meters. You may figure your operating expenses as they were at the time you installed meters, and compare it with the operating expense after setting a good many meters, and you may find no reduction; but, what many people fail to take account of is, how the consumption of water would have increased if the meters had not been put in use. Our pumpage has declined 11% in the last three years, instead of increasing 33%. Five per cent. should be traceable to reduction of the slip of the pumps, owing to our purchase of better pumps. We would have been pumping, without meters, I believe, eleven billion gallons a year more than we are pumping. Multiplying that by $4.68, the cost of coal, labor, oil, packing, etc., to say nothing about depreciation, extra machinery and mains, and you will then get the data for a proper comparison. Again, I think that for a company that can be independent of public opinion to a considerable degree, say a long franchise private company, it might be figured out as not so profitable, but for a municipal plant installing meters universally, although it still would be true that the operating expense would fall, I hold that unless you have a gravity supply where your operating expense does not amount to much, the introduction of meters is almost inevitably accompanied by a reduction of charges. It is almost impossible, however, to introduce meters unless something is done for the public in the way of lower charges to counterbalance what to many is more or less of a nuisance because they feel that with meters they cannot recklessly use water without paying for it. While it is not necessary to reduce rates, old rates will probably work some reduction of revenue the moment the ordinary householder has a meter. On the other hand, a municipal plant has to face this proposition, that when its revenue exceeds a certain margin above operating expenses and interest, there will always be a popular demand for reduction of rates, which you will have to meet anyway; and it is a good deal better to meet it by a system wherein the reduction in revenue will be accompanied by a reduction in expense, especially expenses in construction, rather than to make a reduction in flat rates which benefits the consumer without any benefit to the water department.

Mr. Charles: On this question of water saving effected by meter, being offset by the cost of repairs? We have had fifteen years' experience with meters. We are universally metered, and the repairs on those meters have not equaled 20 cents per meter during the entire time.

They have paid for themselves ten times over, and $10,000 would not pay us to dispense with them. With regard to the question put by Mr. Bemis as to the location of a meter, if your meter readers know their business that is easily settled. The only point of difference between Mr. Bemis and myself is with reference to protection from frost. In his system he brings his meter up close to the surface, and then endeavors to protect it. In my system we put the meter down at the bottom and bring the dial up to the top. Of course, in our warm climate, that works successfully. I do not know how long an extension can be worked with economy. That is a matter of experiment simply. I believe that our system could be used successfully in at least five feet depth of ground; at any rate, I would try it, because I believe that actual experiment is worth all the theories in creation.

Mr. Ford: Up to two years ago I had charge of a water plant in Hartford City, Ind., which was built by Mr. Leopold, of Cincinnati, in 1894. The water supply was derived from sinking wells in limestone. We used water out of these wells for two years, but found that in summer time there was not enough water to supply the demand, and something had to be done. I then carefully investigated the meter question. After writing to the meter companies I found that they were perfectly willing to give us all the information they could about water meters. The great trouble with us was this, that there were but few dwellings in the city supplied with cellars, and that kept us from following that plan. I then took up the question of trying to protect the meters in some other manner than setting them in cellars. I got sewer pipe such as Mr. Bemis now uses, and placed in my back yard two or three of them, putting in the sewer pipe at the bottom a quart bottle of water. I then placed another water bottle half way up. I placed thermometers in different parts of the box. Then I took one box and put an inner lid on an annular ledge half way up, and took readings and kept a careful record. I found the water froze, and broke the bottles in those boxes that were not protected by an inner lid, and after further experimenting I came to the conclusion that a box would protect a meter from freezing if provided with an inner lid. So we put in that manner of boxes and have the plant fully metered, with the result that we have never lost a single meter placed in a box with an inner lid, unless the top of the box had been carelessly left open. The point is, that you must so arrange the apparatus that there shall be no flow of the air from the bottom chamber of the meter box to the upper chamber, nor from this chamber to the outside, because it is the heat from the ground below that must be relied on to protect the meter in the lower chamber. We have never paid one cent for repairs on meters set in boxes in this manner. It is also necessary for us to cut off the water from below, because the nature of our soil is such that in wet weather water rises and would fill the boxes and freeze. Water must also be prevented from coming in in this way from drainage along the curbs of the streets, or it will be impossible to read the meter without first pumping out the water. So we close the bottom of the box. We have two and a half times as many consumers on to-day as we had when, because of the shortage of water, we first investigated the meter question. Our supply of water to-day is the same as it was when plant was installed. I was present at Detroit and heard Mr. Bemis read his article on meter setting. I at that time tried to screw up my courage to ask for further information about his plan and give my own experience in meter setting, but about that time some other order of business came on and I gave it up. After trying these experiments in the winter of 1897, and satisfying myself that it was a successful way of setting meters, I, with another gentleman, took out patents on this process, which are on file at Washington, and copies of the same can be had by any one who wishes to spend five cents with the Government. The patent covers: "A meter-box, a water-tight body, a bottom placed thereto and made water-tight, a cover formed of a rim to rest upon the top of the body and form a water-tight joint therewith, a cover resting on said rim, a cross-bar and bolt for securing the cover to the rim, an annular ledge around the inner surface of the body above the meter-box chamber, and a removable cover on said ledge dividing the box into two compartments, substantially as and for the purpose set forth," etc.

It may be of interest to state that the boxes made now under the patent after the usual evolution that conditions necessitate and experience and convenience dictate, are for a ⅝″ meter, 10″ inside diameter, 3′ 2″ long, exclusive of inlet and outlet pipes, which are of lead: the body water-tight throughout: top lid locked: inlet and outlet pipes and connections tested to 200 lbs. per sq. in. pressure, and the whole weighing 130 pounds.

Mr. Beardsley: One experience that we had in Cleveland might be interesting. There were about sixty meters set on three streets just at the close of last season. Of those 60 I think about 31 or 32 were left without any of these frost covers, as we call them, resting on top of the meter, as we designed it last year. As they were left without any frost covers whatever there was nothing to protect the meter except the iron cover at the surface of the street. Of those 31 or 32 meters there was only one that was frozen. In two other cases the risers leading to the meters were frozen. I give that to illustrate the value of those frost covers.

Mr. Alvord: In answer to Mr. Charles and some others, I would like to point out that you must all recognize, of course, the great difference in operating expenses of a meter system in northern latitudes as compared with southern latitudes. I have no doubt that the operating expenses of a meter system are very materially lower when we get into territory below the line of considerable depth of frost. This is an important distinction that should be kept in mind in discussing this question. I am fully convinced personally of the great value of a meter system judiciously applied, but I am still groping for light as to the value of a universal meter system; and I think we shall get it in the course of a few years.

MR. CHARLES: My estimate of repairs at 20 cents per meter took into consideration all repairs due to the wearing out of the mechanism, or clockwork, which would happen in any climate, in Cleveland or elsewhere. As to frost, our climate, of course, would give us an advantage. We have had no damage from frost in the past year, and we attribute our exemption to our mode of setting meters.

MR. HOUSTON: Just a word in reference to the operating expenses of a plant under the old system as compared with the same after setting meters. In 1884 our population at Kalamazoo was about 18,000. We were pumping about 400,000,000 gallons annually. Ten years later the annual pumpage was about 700,000,000 gallons—nearly double. This was in 1894, when the population was 24,000. Our population now is about 30,000. That time we commenced metering, and our pumpage gradually declined up to the present time when, for last year our pumpage was a little over 400,000,000 gallons, a drop of nearly 50% in the past ten years, with about 2,200 meters set. The system is about 60% metered. Our operating expense is not any more, and our income is now about $5,000 in excess of 1894. Two men attend to our entire meter repairs.

MR. O'SHAUGHNESSY: I think that the question presented by Mr. Alvord would be largely covered by local conditions. We have had an agitation in our town for a greater supply of water, for the last ten years; but being a municipal plant, our people, as in the case of Professor

Bemis, never have been able to agree upon just what to do to increase the supply. In 1895 our city went dry. This is 1904, and we have done scarcely anything yet to increase that supply, excepting to push the meter system. I have every reason to believe that had it not been for the meters, last year, we would have been without water in Columbus. But notwithstanding the addition of 1,160 new services in 1903, we pumped 18% less water than we did the previous year. However, to figure on this matter you will have to take into consideration the local conditions. In Detroit, for instance, they have water to "burn;" the same is true of Cleveland. There are other cities not so situated, where the saving of water is an object; and I think, so far as we are concerned, that we obtained that saving through meters. The citizens of Columbus buy and set the meters themselves. We do not restrict them to any method of setting, but simply instruct them as to what the meter setting means to them, it is their property, and they are supposed to protect it. In case they do not protect it, they have to replace it at their own expense. Severe as last winter was, we had very little trouble with our meters, and I believe that we are in about as cold climate as Cleveland. Our meter readers read the meters each month, and give the people warning if they see anything in exposed condition, that they should have the meter protected. As to friction with consumers, and objections to excessive bills on newly metered services, we of course have some. We do not work under any ordinance at all; our council has nothing to say about our water system. The Board of Public Service fixes the rates and adjusts all claims. If the bill is in excess of what it should be, and the party charged with that bill can show any fair reason why he should be given relief, they give it to him, but for that time only. He cannot come in on next collection day and make the same claim. For instance, if his flat rate bill was $10 and his meter bill $30, they split the difference with him. He gets that adjustment just once; then he is given to understand that he pays for all water that passes the meter thereafter. This plan has worked very successfully.

While it is a great expense to install meters, our people have done it cheerfully, and we have practically no complaints. In the last eighteen months we have set about 7,500 meters. The first of this year, 69% of our services were metered. I think if the Board would go back to a flat rate again, abandoning the meter system, there would be trouble on their hands, because the people seem satisfied. We have an expensive method all the way through. The tap is sold over the counter. We charge from $7.50 to $20 for first cost of tap. It is brought inside of the curbing, and maintained there without further charge for all time. We practically use ¾″ meters altogether.

We are beginning now to remedy the matter of scarcity of water, and I hope, within the next year or two, that we will have water to pump, at least.

Mr. Patton: I have always heard there were two sides to every question, and also exceptions to all rules. I suppose this meter question is an exception, as I have heard very little except from one side either through the journals or in the discussions here. It seems to me that there surely is another side to the question; and if a meter costs $12 to install, which is I believe the ordinary estimate, and if 1,000 meters are installed to-day, they represent an investment of $12,000, upon which there is an annual interest lost; unless that same 1,000 meters are in actual and perfect service ten years from to-day, of if 10% of them are out of service, or have had to be replaced, then we have an additional investment of 10% at least to be added to the annual loss. These meters are something to be considered in determining on the installation of a meter system. Furthermore, the use of meters is comparatively new. They have only been in service for the last few years. What a meter is going to be ten years from to-day, that is, whether it is going to register the same amount of water as it did when first put in, is a question. By whatever percentage its registration decreases, in that proportion arises another element of loss. I would like to hear from some people on the other side of the subject.

VICE-PRESIDENT ROWE: I would like to answer a question Professor Bemis has asked with regard to the method of adjusting reductions where excessive bills appear to have been rendered. We handle that matter in the same way as Mr. O'Shaughnessy does. If a leak is concealed we are willing to make an allowance; if not concealed, we do not do it.

MR. HENRY L. LYON (by letter):

You will hardly expect anything good in regard to Meter Rates to come out of Buffalo, with its exorbitant waste of water. Our great trouble is that we have an unlimited supply, and the people cannot understand why they should not have all they can run through their faucets, and no amount of argument will convince them that it costs to pump water. During the past year I reported to the Water Committee that we were wasting two-thirds of the water pumped, and computed for them the actual expense, taking into consideration only the cost of coal and handling the same, that could be saved if the waste of water could be cut off. I computed this at $270 a day, or $98,550 a year.

A year ago I procured the passing of a new ordinance on meter rates, which I think is an improvement on any I have seen. The ordinance is as follows:

"Chapter 32, Section 77, C-2. No meter, however, will be furnished for any purpose, unless the annual amount per meter is at least

$ 5.00 for a ⅝-inch meter.
10.00 for a ¾-inch meter.
12.50 for a 1-inch meter.
20.00 for a 1½-inch meter.
35.00 for a 2-inch meter.
50.00 for a 3-inch meter.
100.00 for a 4-inch meter.
200.00 for a 6-inch meter.
300.00 for a 8-inch meter.
400.00 for a 10-inch meter.
500.00 for a 12-inch meter.

Said minimum rate to be paid semi-annually in advance."

The effect of the above has been, that people wanting water connections are not so anxious for large ones, but will decide that smaller connections will fully answer their requirements. A large number of old consumers have requested that the size of their supplies be reduced.

The rates seem equitable to me, and based upon a right principle, that is, a sliding rate for the different sized meters. Of course, circumstances might make it advisable to vary these minimums.

MR. D. L. ELLIS, Great Falls, Montana. (Municipal Plant). (By letter):

The installation of meters on 5% of the taps in service has increased the gross revenues 10% and decreased the pumpage 25%.

The meters are owned and set at the expense of the city.

Population 18,620, all supplied with city water.

1,973 taps in service.

5% of taps metered which includes the large consumers only, dwellings are not metered.

Total pumpage for year 1903	635,993,620	gallons
Average daily pumpage	1,741,461	gallons
Highest daily pumpage (Aug. 19)	2,871,000	gallons
Lowest daily pumpage (Jan. 9)	1,324,000	gallons
Average gallons per capita	93	
Total revenue for year	$49,420.69	

Average revenue per tap, Municipal ownership,	24.54
Average revenue per tap when plant was owned by private company	44.27

METER RATES.

By John B. Heim.

Superintendent City Water Works, Madison, Wis.

Our annual gatherings are not only an outing, but a school of instruction. We come to learn from each other of the experiences gained during the time since last we met—of the obstacles we encountered and how we overcame them. We renew our friendship. Increase the number of our friends. We exchange the thoughts uppermost in our minds as to how we can better our work entrusted to us by a confident community. We learn and instruct. Some of us express our minds on the floor of the convention, in presenting ideas, views, experiences and successful accomplishments, either in talk or manuscript, give them for the benefit of the association. Others in conversation with brotherly tendencies, so, that when we return home, it is with renewed vigor and better equipment to battle with another years work.

During the winter of 1903, we had a contest in our city regarding meter rates. The contention was that there should be a so-called flat rate. I would call it a uniform rate, as it is the same rate per one hundred cubic feet or gallons for the large or small consumer. The word *flat* rate is a misnomer. Webster gives the explanation of flat as follows: "To flat out, to fall from a promising beginning; to make a bad ending; to disappoint expectations." That would be the correct definition with us, should we have adopted the flat rate. As it is, this discontended agitation of the meter rates lost us one of our large consumers, and indications are, that we may lose more. Another contention was, that we should dispense with the minimum rate. The amount paid annually should be for only the actual amount of water consumed, regardless of the investment incurred in laying mains and service connections free to the consumer; besides furnishing the meter free, and including the daily service rendered. You might as well sell the coal by the single pound; wood by the stick; or sugar by the single ounce, at the same price as per ton, cord or pound. That would be just as consistent as to sell water by the gallon at the same rate for the large and small consumer without a minimum.

In ye olden times, the citizens were obliged to go to the town pump or well, exerted themselves to get and carry the water to their domicile and perhaps unbeknown, paid a tax for this privilege.

In our days the water works system not only pumps the water, but carries it to the individual's fixtures and appliances in his abode for the convenience and comfort of those that desire the commodity at their command. And that at all times whether by day or night and at all seasons of the year. It is the town carrier of the most necessary article at the smallest expense of all public utilities. Aside from that it performs the mission of fire protection free of cost.

The energy demanded in the performance of this duty and the expense incurred is lost sight of by a great many water consumers. It is with them in the purchase of water as with all other purchases. They still go to the market with the basket as of old. They want the best and pay the least. They are niggardly in all their dealings. They envy their brother and still he shall foot their bills. They buy ten cents worth of meat for dinner and are willing to carry it home. But from the water works still more is expected. They want the water and the pressure at any moment of the day for fifty cents a year or even less, when the cost of operation, as in our case in 1902, was on an average of $4.31 per consumer, without considering the average interest on the investment. All of you I expect have had this same experience with the make up of such individuals, as have all business men.

This class of citizens brought on the agitation with us in Madison. The socialistic and political tendencies commenced to show their heads. The demagogue, ever ready, raised the rich and poor cry.

Milwaukee, Wis., with its estimated population of 308,000, and 38,000 consumers, was held up against Madison with an estimated population of 20,000 and 3,132 water consumers, as the ideal city. Selling its water at a uniform rate of 4½ cents per 100 cubic feet, and without a minimum. The business part of the affair was not allowed to predominate, as how it is possible for Milwaukee to sell water at such a low rate. I will not consider the unfairness of the vast difference of the two cities in population. Nor the inexhaustible supply of Lake Michigan against our artesian wells, compelling us to pump our water twice for storage. The cheapness of coal, it being a lake city. Their pumping station located at the lake shore, using soft coal at $2.90 per ton, against our inland city, compelled to use hard coal on account of our pumping station being located in the residence portion, paying $6.98 per ton, an excess of $4.08 per ton over Milwaukee.

I will consider the income of both cities as a comparison. Our rate was at the sliding scale of from 5 to 20 cents per 100 cubic feet, with a minimum of $4.50 per annum.

Of the 3,132 consumers, 1,204 paid us only the minimum, or $5,418.00 for the year. Our total income was only from water rents, as we had no other resource, and amounted to $29,250.46. An average of $9.34 per consumer. We pumped 458,850,100 gallons of water. Of this amount 278,000,000 gallons was free water. Milwaukee pumped 9,128,941,230 gallons, furnished no free water. Milwaukee's income from water rents was $431,832.95, or $11.36 per consumer. From other sources it received as follows: Street sprinkling, $15,-

203.26; laying of water mains, $38,050.53; taps and branch permits, $12,633.00; hydrant rental, $20,824.14; from general city fund, $6,012.82; fire department, $782.75; police department, $392.00, and $1.00 each for reading 33,817 meters, $33,817.00. A total of $127,715.50, or $3.36 per consumer. Total average per consumer of $14.72, against our $9.34, in favor of Milwaukee of $5.38. Milwaukee has any number of large takers and they pay as high as $37,000.00 per annum. We have only five large takers paying us from $325.26 to $587.90 per annum.

Our average operating expenses in 1902 was $4.36 per consumer against Milwaukee $4.42. Receipts in our case over operating expenses per consumer, $5.18. Milwaukee, $10.30. If we had reduced our rate as was contended to 4½ cents per 100 cubic feet, with no other resource or income, we would have received only $6,289.59, or $7,271.10 less than our operating expenses. Whereas under our scale rate we received on an average a trifle less than 8 cents per 100 cubic feet and Milwaukee with its resources received a trifle over 10¾ cents per 100 cubic feet. These authentic facts and figures show that the mere statement, that Milwaukee sells its water at 4½ cents per 100 cubic feet without giving the resources of income in addition, is all wrong. On February 24, 1904, an article appeared in a paper published at Appleton, Wis., where the contention of the city and the water company was at a high tension, giving copies of water bills paid by citizens of Milwaukee, which had been published by the National Democrat of Sheboygan, Wis., and claimed were received from the water registrar of Milwaukee and on exhibition in the office, that read as follows:

WATER RENT FOR THREE MONTHS.

Residence, No. 1214 Richards street	.59
Flat containing seven families, No. 2968, 1st ave. .	$1.83
Tenement, No. 458 Lapham street	.30

Tenement, No. 903 Bartlett street	.43
Tenement, No. 854 Newhall street	.57
Tenement, No. 755 Booth street	.75

These bills do not show the charge of meter reading, which should have been added to the bill. Probably the charge of $1.00 for meter reading is collected once a year. To this should be added when information is sent out, the $3.36 per consumer from other sources paid as a tax, by the property owner. That would make the above bills read respectively, $6.72, $11.68, $5.56, $6.08, $6.64 and $7.36 per annum. A total amount of $44.04. While with us in Madison, the amount would only have been at the minimum of $4.50 each, or $27.00 per annum.

This shows the injustice that is done to other water departments, endeavoring to show how cheap water is sold without giving the fullest statement.

The water rent question is what confronts most every water department, laboring under such delusions, and it is the reason why I cover the above instance so fully.

The agitation in our city becoming very marked, a special committee of the board of water commissioners was appointed to look into the matter, to reduce if possible the meter rates and also to consider the question of the minimum rate. To aid the committee in its labors we had question blanks prepared and forwarded them to about 200 water departments, as to their population; water system; source of supply; number of consumers; number of meters; gallons of water pumped for the year; the amount that passed through the meters; what kind of meter rate; whether they recommend a flat rate; their minimum; annual income from water rents; from other sources; operating expenses; kind of fuel; price per ton, etc.

Of these two hundred we received 135 answers, 88 of which were very complete. These 88 I have tabulated for the benefit of the members of the association, under the head of water works statistics, to accompany this paper. The chart is 32 x 106 inches, and will remain in the convention hall during the session, and a reduced copy be printed in the Proceedings.

The information given is very concise, giving a complete history of each department. It is authentic and gives the name of the informant. It was a very laborious piece of work and I trust it will be a help to those interested in the doings of other departments, and act as a guide for the future. Of 31 other answers I will give only the amount received per consumer. The main question at issue, to wit, the flat or uniform rate and the minimum was awaited with a great deal of interest.

Of all the answers received, only eighteen favor a flat rate. Two others have a flat rate, but favor a scale rate and most of the eighteen use meters only for large consumers.

Some of those that answered *No* to a flat rate, emphasized their opinion in the following language.

No! "I think it should be graduated."
No! "Decidedly No."
No! "With us it would not be practicable."
No! "We would lose our large consumers."
No! "I would not recommend it."
No! "Not for cities of our size." (Population 10,000.)
No! "The large consumers' rate must be lower."
No! "Manufacturers should have a special rate."
No! "We think the scale rate works well for all."
No! "Do not believe it fair or expedient."
No! "On sliding scale only."
No! "Not for our city."
No! "Never."
No! "Think the scale rate better."
No! "Not if works are self sustaining."
No! "My preference would be for a sliding scale."

No! "Not yet."

"The subject interests me. I have not arrived at the point of making a recommendation."

No! "Think it impracticable."

No! "We favor large consumers."

No! "Considerale argument both sides."

No! "Graded according to amount used."

"This is a big question and could hardly be answered the same for two cases."

No! Large consumers should have the benefit of lowest rate on sliding scale."

F. H. Crandall, Superintendent of water works, Burlington, Vermont, answered: "We found, on investigation some few years ago, that a flat rate, yielding about our present income, would furnish to the large number of small takers all the water they were in the habit of using for less than cost of meter and service maintenance. As the commissioners were of the opinion that the furnishing of water to the smaller takers at less than cost, and at the expense of the larger takers, was no more reasonable and right than the furnishing to the large takers of water at less than cost and at the expense of the smaller takers, the flat rate was not adopted, but instead a sliding scale, so worded as to afford no opportunity for larger quantity of water being obtained for no increased assessment, with a minimum rate clause."

John F. Sprenkel, General Manager of the York, Pa., Water Company, answered, "We do not think it advisable to establish a flat rate, one and the same rate for all consumers, large and small, as you suggest, for this reason. Some consumers' residences will require anywhere from 8 to 50 feet or more of pipe laid, whereas the amount of water consumed may not be more than three or four gallons per foot of pipe per day. Further on you may have a manufacturing plant which may require possibly one or two hundred feet of pipe and may consume from ten to fifteen thousand gallons per foot of pipe. Naturally, they requiring you to lay so much less pipe, less service pipe, less expense for metering in proportion to the quantity of water consumed, their rate should be very much smaller. On that account we have made our sliding scale by which, as you will note, all consumers pay the same rates. For the first 10,000 gallons every consumer pays 30 cents per 1,000 gallons. For the next 40,000 gallons, or a total of 50,000, they pay 11 cents per 1,000, or a total of $7 40 for the 50,000 gallons. Where a consumer uses more than one meter we charge 50 cents a month meter rent, although this meter rent should be charged in proportion to the size of the meter. We revised our meter rates two times before we reached our present conclusion."

Of eighteen that favored a flat rate, five emphasized their answers as follows:

Yes! "Except for railroads."

Yes! "Appears to be satisfactory."

Yes! "All except manufacturers."

Yes! "It being the citizens' plant. Yes."

Yes! "It would seem to be a just thing to do, where plant is owned by the city."

All of the five above have a minimum rate of from $4 to $10 per annum, which does not harmonize with a flat rate.

Three cities favor a flat rate that have no minimum, viz: New Britain, Conn., with a rate of 7 cents per 100 cubic feet, 40 per cent. taps metered. Milwaukee, Wis., a rate of 4½ cents per 100 cubic feet, $1 extra for reading the meter, and a resource of $127,755.45, 90 per cent. metered. Cincinnati, Ohio, with a rate of from 6½ to 8 cents per 100 cubic feet (which is not a flat rate), a resource of $54,644.84, and four large consumers varying from $7,600 to $25,000 per annum, only 8¾ per cent. metered. Detroit, Mich., says Yes! and has a sliding scale from 2½ to 6 cents per 1,000 gallons. Received from general tax $75,000, and from other sources $33,388.03, a total of $108,388.03; with a minimum rate of $7 per annum (which does away with a flat rate), only 10 per cent. metered. Manchester, N. H., says Yes! and has a flat rate of 12½ cents per 100 cubic feet. Receives a hydrant rental from the city of $19,200, and has a minimum of $10 per annum, 65 per cent. metered. Yonkers, N. Y., says Yes! and has a flat rate of 15 cents per 100 cubic feet. Received a hydrant rental of $23,880, has several large consumers, ranging as high as $12,630, and a minimum of $4 per annum, 100 per cent. metered. Spokane, Wash., says Yes! Has a flat rate of 15 cents per 1,000 gallons. A minimum of $18 per annum. Meter percentage not given. The minimum would indicate only large consumers are metered. New Brunswick, N. J., says Yes! Has a flat rate of 10 cents per 100 cubic feet. Received a hydrant rental of $11,700, and has a minimum of $10 per annum, only one per cent. metered. Meadville, Pa., says Yes! Has a scale rate of from 5 to 15 cents per 100 cubic feet. Has a minimum of $5 per annum, 10 per cent. metered. Question must have been misunderstood. Los Angeles, Cal., says Yes! Has a flat rate of 7 cents per 100 cubic feet. Minimum and per cent metered not given. Lynn, Mass., says Yes! Has a flat rate of 15 cents per 100 cubic feet, and a minimum of $10 per annum; 25 per cent, metered. Grand Rapids, Mich., says No! It has a flat rate of 5 cents per 100 cubic feet and a minimum of $5 per annum; 20 per cent. metered. Minneapolis, Minn., says No! Has a flat rate of 6 cents per 100 cubic feet. A minimum of $4 per annum; 33 1-3 per cent. metered. A water department that collects a minimum I do not consider it strictly under a flat rate. Certainly not one that has a scale rate and a minimum.

Of the 88 answers as to minimum, 69 cities have a minimum ranging from $3 to $24 per annum. One city's minimum is up to $40, another up to $100 per annum.

Seven cities have no minimum and eleven cities failed to answer the question.

Buffalo, N. Y., has the lowest meter rate, varying from ½ to 4½ cents per 100 cubic feet. Only 2 per cent. metered, a minimum of $24 showing that only manufactories are metered. Besides it receives a hydrant rental of $70,500 per annum. Albany, N. Y., has a scale rate of from 3¾ to 6 cents per 100 cubic feet; 17 per cent. is metered. Received $10,254.96 from other sources. Has one large consumer that pays $30,000 per annum and has a minimum of $5 per annum. Providence, R. I., is one of the cities that has the best financial results. It sells water at from 12 to 15 cents per 100 cubic feet. Received $31,397.31 from other sources. The receipts from its large consumers vary from $1,000 to $30,000. It has a minimum of $10; 82 per cent. metered. The amount collected from 22,758 consumers amounted to an average of $28.60 per consumer per annum. Sedalia, Mo., is still better. The meter rate is 12½ to 30 cents per 100 cubic feet. Received $10,600 hydrant rental: 10 per cent. metered. The average per taker received was $50.90 per annum.

This gives you a fair idea of the variance and financial results of different water departments. The perusal of the statistics given on the chart will give you further information. I have also tabulated the 31 cities mentioned, incomplete for the chart, but worthy of consideration in the financial results. I give the estimated population, the average amount received per taker from the water rents; other resources and the total average per consumer.

Place.	Pop.	Av. Amt. Water Rent.	Av. Amt. other sources	Tot. Av Amt. rec'd per consumer
Columbus, Wis.	2,400	$10.27	$8.34	$18.51
Austin, Minn.	6.000	9.02	....	9.02
Yarmouth, Nova Scotia .	6,500	18.80	2.97	21.77
Trinidad, Col.	7,500	22.43	6.51	28.94
Goshen, Ind.	9,000	5.59	23.70	29.29
Grand Island, Neb.	9,000	16.66	....	16.66
Mason City, Iowa	9,000	12.50	3.12	15.62
Ispheming, Mich.	15,000	7.56	....	7.56
Gloversville, N. Y......	19,000	12.18	.03	12.21
Concord, N. H.	19,632	17.11	2.23	19.34
Poughkeepsie. N. Y. ...	24,400	10.73	.40	11.13
Hamilton, Ohio	25,000	8.60	1.02	9.62
Newburgh, N. Y.	25,000	9.65	.05	9.70
Gloucester, Mass.	29,000	14.00	2.68	16.68
Colorado Springs, Col...	30,000	15.00	....	15.00
Fitchburg, Mass.	32,000	14.30	....	14.30
Jacksonville, Fla.	33,000	15.00	5.62	20.62
Auburn, N. Y.	35,000	13.63	3.63	17.26
Atlantic City, N. J......	36,000	22.58	5.53	28.51
Binghamton, N. Y.	40,000	11.18	2.32	13.50
Pawtucket, R. I.	40,000	23.62	2.51	26.13
Altoona, Pa.	45,000	7.10	.33	7.43
Fort Wayne, Ind.	50,000	7.33	.59	7.92
Evansville, Ind.	65,000	13.61	....	13.61
Waterbury, Conn.	71,000	31.33	....	31.33
Camden, N. J..........	75,000	11.72	....	11.72
Lowell, Mass.	95,000	17.36	....	17.36
Allegheny, Pa.	135,000	12.59	....	12.59
New Orleans, La.	300,000	45.51	13.85	59.36
Cleveland, Ohio	395,000	9.67	.07	9.74
Baltimore, Md.	524,000	7.82	.29	8.11

From all of this information received, considering our city under all conditions, the committee selected, proceeded to work, going over all details. First it considered the rate, whether a flat or uniform rate, or as heretofore, a sliding scale, should be adopted. It invited the public to a full and free discussion of the subject. The discussion developed such wide and radical differences of opinion, amounting to an apparent antagonism of interest between large and small consumers, that it was only fruitful in stimulating the committee to give the matter the best and largest possible consideration, so that its results and recommendations would meet the approval of the largest possible number of citizens and patrons.

The question of uses of water was first considered and classified into domestic, commercial and public or free and unaccounted for water. The last item was considered as one. The results obtained did not differ materially from the general expression of other cities in the use of free water. Our percentage of such uses being, however, greater than the average. The conclusion arrived at, was that the public use should be charged on the whole community and not only on the water consumers. That a sum of $10,000 of the general taxation should be set aside by the common council, to make up the deficiency in the water rents, caused by a reduction in the meter rates. This is not more than fair and just. There is no reason why the water consumers should pay for their own and also contribute their share in water rent for the free water used in public buildings, schools, churches, charitable institutions, street sprinkling and fire protection.

Another injustice to the water consumer is, when it compels them to pay for laying of mains and service connections at the expense of the water department out of the water rents. This should be paid out of the general city fund, or by the owner of the property benefited, as in other cities. The next step was the domestic and commercial use, in which enters the large and small consumers, and the proper distribution of the meter rates. The committee approached the matter without bias or prejudice and was unable to escape the conclusion, that the large water consumers are the most profitable to the department under a sliding scale. After weeks of labor the committee came to the following conclusion when it says: "Our present sliding scale rate is the result of the departments efforts to decrease cost of service to all consumers, and is approved by this committee as being founded on equity and good business principles." These rates I formulated in 1896 for the commissioners. It is a satisfaction to have an approval of such scrutiny of the work performed at that time and continued ever since. The committee further says, "From a study of the results obtained under same, we are, however, of the opinion that the consumer who, by lawn sprinkling or free domestic use of water, runs up to $10 or $15 per six months, pays rather the most in proportion, and in view of this possible fact, and of other recommendations in the report, and further of our expected increase in the supply of water, we are of the opinion that the present rate of 20 cents per unit for the first 5,000 cubic feet above the minimum be reduced to 13 cents per 100 cubic feet, and recommend such reduction and that the present *sliding scale* be continued in force with above modification, with 5 cents per unit as the lowest price at the end of the scale. The committee feels that this discussion of water rates is elementary and crude, and that it does not add anything of value to the board's information on the subject, but in so far as it confirms the present use of the sliding scale, it is, at least to this committee of the board a satisfaction to know that our past methods are approved by our present judgment, and we trust that the discussion will be received and continued by the public in a spirit of fairness one to the other, as well to the water board as a whole, and without any attempt to shift the burdens and obligations of modern high living, as there are, after all is said, greater benefits and return from the comparatively small amounts which each one expended or contributed for any other purpose.

Public uses of water should be paid for by an annual addition to the tax levy for the benefit of the water fund, of the sum of $10,000, or such sum as experience and the judgment of the water board shall determine. We recommend the minimum charge for all water users to be reduced from $4.50 to $4 per annum, or 1,500 cubic feet per six months, before any further charge accrues. That the charge of 5,000 cubic feet of water, above the first 1,500 feet per six months shall be at the rate of 13 cents per unit for 100 cubic feet. For quantities over 5,000 feet and up to 20,000, 10 cents for each additional 100 cubic feet, according to our present scale, with 5 cents per 100 cubic feet as the lowest price. That all bills rendered and all receipts given show plainly that computations are made as above."

The recommendations and accompanying schedule of rates by the special committee was adopted unanimously by the board of water commissioners. As an illustration under the new rate adopted, a bill for 230,000 cubic feet of water for six months would be as follows:

First 1,500 cubic feet (minimum)	$2.00
Next 5,000 cubic feet, at 13 cents	6.50
Next 15,000 cubic feet, at 10 cents	15.00
Next 208,500 cubic feet, at 5 cents	104.25
Total, 230,000 cubic feet	$127.75

Under this rate it can be seen that the large consumer pays the same rate as the small consumer until he gets beyond the wants of the small consumer, when the lower

WATERWORKS STAT

COMPILED BY JOHN B. HEIM, SUPERINT

A. D 1904

No.	City	State	Population		Year Commencing	Water System				Owner	Source	Filtered	Annual Pumpage gals	No. of Consumers	Water passing Meters in gals	Estimated free Water	% metered	Scale Rate	Flat Rate		Annual Minimum Rate	Annual Income from Water Rents	Average per Consumer	Annual Income from other Sources				No. of Hydrants	Hydrant rental		Aver. [illegible] from other sources	Am't from all Sources	Total per Taker	Amount rec'd from large Consumers
			Census	Estimate		Direct	Std Pipe	Reservoir	Gravity										used	recommended				General tax	Taps, per units, etc	Street sprinkling	Laying Mains		Price per Hydrant	Am't received				
1	St Peters	Minn.	4302	4500	Apr. 1,'01–Apr. 1,'02		yes			City	Artesian Well	no	not given	208	4510000	not given	100	30 cts per 1000 gals			$3 00	$1480 00	$7 11	$	$	$550 00	$	50	$45 00	$2250 00	$5 40	$4280 00	[illegible]	$300 00 – 600 00
2	Tanners Falls	N.Y.		5000	May 1,'01–Apr. 30,'02			yes		,,	Lake Pleasant	,,	185550000	485	not given	1000000	1	flat rate	yes	yes	6 00	8500 00	17 58	5500 00	none			60	no		11 32	14000 00	28 84	300 00 – 57 00
3	Delaware	Ohio	7940	9500	Nov. 1,'01–Oct. 31,'02		,,			Co.	Wells	,,	175544143	1050	,, ,,	10000000	40	16⅔-3 c per 100 cu ft		no	none	10000 00	9 52			650 00		235	200 @ 37 50 35 ,, 20	8550 00	8 14	18550 00	17 66	900 00 4300 00 3[illegible]
4	Hudson	N.Y.	9528	10000	Jan. 1,'02–Dec. 31,'02			,,	,,	City	Hudson R.	yes	550000000	1600	8000000	542000000	2	64 ,, ,, 1000 gals		,,	,,	3500 00	2 15	10000 00				200	no	none	6 25	13500 00	8 44	275 00
5	Meadville	Pa.	10291	10000	,, ,,				yes	,,	French Cr.	no	730000000	2000	not given	,, ,,	400 meters in use	13-5 ,, ,, 100 cu ft		yes	5 00	30000 00	15 50			200 00		131	,,		10 00	30200 00	15 10	500 – 400 00
6	Watertown	Wis.	8437	10000	Oct. 1,'01–Sept. 30,'02	yes	,,			,,	2 Art. Wells	,,	135132839	509	57582165	14500000	41	16⅔-6 ,, ,, ,, ,, ,,		no	5 00	6539 35	12 65		,,	750 00		157	,,	,,	1 48	7289 35	14 33	1156 36 684 30 90 00 50 00
7	Valparaiso	Ind.	6280	10000		,,				Co.	Flint L.	,,	13000000	2000	not given	none	33⅓	not given		,,	not given	not given						102	1st 50 @ 55 over ,, ,, 35	5300 00	2 63			
8	St. Catharines	Ont.	10092	10092	Jan. 1,'02–Dec. 31,'02				,,	City	L. Erie	,,	not given	2444	26639685	not given	1	12-6 c per ,, ,, ,,		,,	10 00	21115 37	8 44	7543 12		475 00		269	20 00	5380 00	5 37	34513 49	13 05	603 83 397 44 206 22 200 [illegible]
9	Iron Mountain	Mich.	9342	11000	,, ,,	,,	,,			Co.	Art. Well	,,	212970000	1600	87922000	14000000	12	22½-6 ,, ,, ,, ,, ,,		yes	5 00	15757 51	9 03					174	58 00	9864 00	6 [illegible]	25221 51	16 01	1468 00 1447 00 2[illegible] 68[illegible]
10	Little Falls	N.Y.	10381	11000	May 1,'01–Apr. 30,'02				,,	City	Mtn Trout Streams	yes	1095000000	1859	not given	not given	2		,,	no	10 00	27295 14	14 68	6500 00				140		6500 00	6 39	13000 00	21 67	2250 14 – 472 14
11	Peru	Ind.	8463	12000				,,		,,	Wells	no	510000000	1500	,, ,,	300000000		20-3		,,	5 00	17000 00	11 33		500 00	none		101	no		0 54	17500 50	11 67	3000 00 1200 00 300 00 15[illegible]
12	Marshalltown	Ia.	11544	14000	Mar. 8,'01–Mar. '02	,,				,,	,,	,,	553767782	1937	,, ,,	114327782		30-2 ,, ,, ,, ,, ,,		,,	4 40	21314 30	11 00	4200 00				240			2 17	25514 30	13 17	1020 00 3000 00 2000 00
13	Wausau	Wis.	12354	14000	Jan. 1,'02–Dec. 31,'02	,,				,,	,,	,,	596501123	1600	,, ,,	not given		20-4 ,, ,, ,, ,, ,,		,,	5 00	18554 35	11 59					170				18554 35	11 59	300 00 270 00 125 00
14	Clinton	Mass.	13667	14000	Feb. 1,'02–Jan. 31,'03	,,	,,		,,	,,	Springs	,,	not given	1759	250109900	,, ,,	37	23-6½ ,, ,, ,, ,, ,,		,,	6 00	26539 62	15 09			160 00		172		5160 00	3 02	32019 62	18 20	2558 45 442 49 314 26
15	Woburn	,,	14254	14500	Jan. 1,'02–Dec. 31,'02	,,				,,	Filter Gallery	yes	444000000	3000	42000	35000000	10			,,		42000 00	14 00	900 00		250 00		352			0 30	43150 00	14 20	800 00 600 00
16	Ann Arbor	Mich.	14509	15000				,,		Co.	Wells	no	469000000	2200	few meters	none	1					39000 00	16 04		3884 11			155		6700 00	3 04	45700 00	19 68	
17	Marlboro	Mass.	13609	16000					,,	City	L. Williams	,,	199000000	1500	66500000	not given	50	33⅓-11¼			6 00	34551 28	23 02					339		6750 00	4 30	4129 09	27 12	365 00 469 47 52 00
18	Norwich	Conn.	17251	17000	Apr. 1,'02–Mar. 1,'03			,,	,,	,,	Wells	,,	not given	3900	200000000	,, ,,	25	22½-5½ ,, ,, ,, ,, ,,		,,	not given	56000 00	14 36			250 00		330	no		0 04	56250 00	14 42	800 00 600 00 500 00
19	Sedalia	Mo.	15251	17000		,,	,,			Co.	River	yes	500000000	1000	not given	,, ,,	30	30-12½ ,, ,, ,, ,, ,,		,,	,,	39500 00	39 50	300 00 to 500 00		300 00		185		10600 00	1 40	50[illegible]00	50 60	3600 00 3000 00 800 00
20	Steubenville	Ohio	14349	17000	Feb. 1,'02–Mar. 31,'03				,,	City	Ohio R.	no	771000000	3500	162000000	681000000	2½	37½-3¾ ,, ,, ,, ,, ,,		yes	10 00	30000 00	8 73		100 00			207	,,		0 02	30000 00	8 59	2500 00 300 00
21	Middletown	Conn.	9589	18000	Jan. 1,'02–Dec. 31,'02				,,	,,	Impounding Res	,,	not given	3600	70836000	300000	13		,,	no		30866 00	8 58					209		5465 00	2 39	36331 00	11 17	535 06 421 61 332 85
22	New London	Conn.	17548	19000	Sept. 1,'01–Sept. 1,'02				,,	,,	Storage R'svrs	,,	476475000	3361	not given	not given	38	22½-4½		,,	10 00	51662 02	15 37					328				51668 02	15 27	2628 00 200 00
23	Northampton	Mass.	18643	19000	Dec. 1,'01–Nov. 30,'02	,,			,,	,,	Mtn. Streams	,,	not given	3000	140047616	,, ,,	40 meters in use	7½-4½ ,, ,, ,, ,, ,,			[illegible]	39753 00	13 25					303				39753 00	13 25	2399 71 2 653 35 368[illegible]
24	Burlington	Vt.	18640	19200	Jan. 1,'02–Dec. 1,'02			,,		,,	L. Champlain	,,	293586475	3464	137649325	none	54	13-6 ,, ,, ,, ,, ,,		,,	6 00	42817 47	12 36			1425 82		177	20 00	3540 00	1 40	46357 47	13 76	573 00 558 45 468 20
25	Fort Smith	Ark.	11587	20000	,, –Dec. 31,'02	,,	,,		,,	Co.	River	,,	550000000	2025	80000000	50000000	645 meters in use	18⅓-7½ ,, ,, ,, ,, ,,		,,	3 90	39000 00	15 70					124	30 00		3 06	39000 00	16 76	3000 00 720 00 600 00
26	Madison	Wis.	19164	20000	Oct. 1,'02–Sept. 30,'02	,,				City	Art. Wells	,,	462424400	3132	139568692	278000000	95	20-5 ,, ,, ,, ,, ,,			4 40	29250 00	9 34		332 00	none	none	194	no			29582 46	9 34	587 00 489 28 335 4[illegible] 334 25
27	Pueblo	Col.	28157	20000		,,	,,			,,	Arkansas R	,,	1750000000	3800	no record	no record		4½-18⅓ ,, ,, ,, ,, ,,		,,	not given	78000 00	20 33					340	1st 30 @ 60 00 over ,, ,, 45 00	16920 00	3 70	94820 00	24 22	2400 00 2000 00 750 [illegible] 500
28	New Brunswick	N.J.	20006	21000	Jan. 1,'02–Dec. 31,'02			,,	,,	,,	Lawrence Brook	,,	766674888	3339	not given	not given	215 meters in use	100 ,, ,, 1000 ,, ,,		yes	10 00	70703 14	21 17			600 00		234	50 00	11700 00	3 90	83003 14	25 15	5000 00 1410 00 2000 00 5[illegible]
29	Decatur	Ill.	20754	23500		,,				,,	Sangamon R.	yes	900000000	2300	,, ,,	275000000	25	11-3 ,, ,, 100 ,, ,,			8 00	52000 00	[illegible]			200 00		210	no		0 08	32200 00	13 99	4000 00 2500 00 2500 00
30	Elgin	,,	22433	24000		,,				,,	Fox R.	,,	706577941	3127	116026242	13786400	12	13-2 ,, ,, ,, ,, ,,		,,	4 00	30073 00	9 60					385	,,	none		30013 60	9 60	527 70 421 0 312[illegible]
31	Battle Creek	Mich.	18563	25000	Jan. 1,'02–Dec. 31,'02		,,			,,	Goguac L.	no	438000000	2935	205000000	100000000	84	8-9⅓ ,, ,, ,, ,, ,,		no	3 00	25227 00	8 56		4009 41	70 00		412	,,		1 34	25297 00	9 65	3700 00 1430 00 [illegible]
32	Nashua	N.H.	23898	25000	Oct. 1,'01–Sept. 30,'02	,,		,,		Co.	Springs	,,	1301402064	5000	about 50%	none		15-3¾ ,, ,, ,, ,, ,,		,,	16 00	not given				700 00		245	30 00	7350 00	1 61			3000 00 500 00
33	Waltham	Mass.	23481	25000	Feb. 1,'02–Jan. 31,'03		,,	,,		City	Rivers	yes	688828180	3520	31425150	86000000	6	16-13 ,, ,, ,, ,, ,,			8 00	70000 00	9 88					350				70000 00	9 88	1525 00 1 250 00 7 500 650
34	Aurora	Ill.	24147	26000			,,			,,	Art. Wells	no	579219580	3400	386146374	183073187	100	15-8 ,, ,, ,, ,, ,,		,,	4 50	25639 50	8 71					467	no			25639 50		700 00 600 00 500 00 3[illegible]
35	Oswego	N.Y.	22199	30000	Jan. 1,'02–Jan. 1,'03	,,			,,	,,	Oswego R.	,,	604798414	2296	not given	not given	10	16⅔-3 ,, ,, ,, ,, ,,		,,	10 00	31017 75	13 50		1219 62			327	,,		0 53	32237 67	14 03	400 00 1200 00 600 00 700 [illegible]
36	Bay City	Mich.	27628	30000	,, –Dec. 31,'02	,,				,,	Saginaw Bay	,,	1069661847	2200	193576393	300000000	42	3⅓-7½ ,, ,, ,, ,, ,,		,,	6 00	24544 00	11 15					424				24544 00	11 18	550 00 530 00 420 00 360 00
37	Jackson	,,	25180	30000	Mar. 1,'02–Mar. 1,'03	,,				,,	Art. Wells	,,	857526160	3568	not given	not given	20	75c 60c per 1000 gals per mo		yes	4 00	36000 00	10 40					511	,,			36000 00	10 03	
38	Kalamazoo	,,	24404	30000	Apr. 1,'01–Mar. 31,'02	,,				,,	Wells	,,	437283478	2500	,, ,,	56806852	80	10-6 c per 100 cu ft		no	3 00	20970 00	8 30			200 00		425	,,		0 78	22863 50	9 14	444 36 196 15 162 50
39	New Britain	Conn.	25998	31000	Apr. 1,'02–Apr. 1,'03	,,				,,	6 sq. mis H_2O shed	,,	not given	3322	214000000	not given	40	7½ ,, ,, ,, ,, ,,	,,	yes	none	63000 00	18 56			100 00		378	,,		2 87	63100 00	21 03	1200 00 750 00 737 00
40	Taunton	Mass.	31036	31000	Dec. 1,'01–Dec. 1,'02	,,				,,	Ponds	,,	565717831	4906	245734618	,, ,,	43	23-9 ,, ,, ,, ,, ,,		no	10 00	65000 00	13 23					803	,,			65100 00	13 25	450 00 1500 00 600 00 500 [illegible]
41	Woonsocket	,,	28204	34474	,, –Nov. 30,'02		,,			,,	Crook Fall Brook	,,	360211747	not given	278268469	,, ,,	86	7½-22 ,, ,, ,, ,, ,,		,,	10 00	58540 00	8 49	2187 36		1483 95		571	7 00		5 69	63610 66	14 [illegible]	2898 50
42	Rockford	Ill.	31051	35000	Jan. 1,'02–Dec. 31,'02	,,				,,	Art. Wells	,,	1071892828	3307	80000000	,, ,,	10	not given		yes	6 00	42000 00	10 80			500 00		402					10 [illegible]	866 15 3402 1 2435 2
43	Newport	Ky.	28301	35000	,, –Jan. 1,'03			,,		,,	Ohio R.	,,	648973000	5200	200000000	150000000	47 meters in use	6-11 c per 100 ,, ,,		no	6 00	31000 00	9 00		2000 00			250	no	none	0 36	33000 00	10 [illegible]	3900 00 2700 00
44	Mobile	Ala.	38469	39000	Feb. 1,'02– ,,			,,	,,	,, & Co.	Creeks	,,	not given	not given	89845279	110000000	1.5	11-3 ,, ,, ,, ,, ,,		,,	9 00	48000 00	8 47	5680 00				650	,,	,,	1 00	53680 00	9 47	1600 00 300 00
45	Joliet	Ill.	29353	40000	July 1,'01–July 1,'02	,,				City	Art. Wells	,,	995000000	3000	35000000	not given				,,	not given	25000 00	8 03									25000 00		300 00
46	Springfield	Ohio	38253	40000	Apr. 1,'01–Mar. 31,'02		,,			,,	Wells	,,	1218000000	4480	not given	,, ,,	5	7½-4½ ,, ,, ,, ,, ,,		,,	10 00	42747 00	9 50	3896 00		900 00		453			0 87	47543 00	10 [illegible]	4800 00 1200 00 800 00 600
47	Brockton	Mass.	40063	40063	Dec. 1,'01–Nov. 30,'02		,,			,,	Storage Reservoir	,,	497300329	5671	269275273	60000000	90	22½-12 ,, ,, ,, ,, ,,			8 00	90433 13	19 43					696		3000 00	0 52	93433 13	19 97	1695 93 1442 70 1381 00 55[illegible]
48	Lincoln	Neb.	40169	41000	Sept. 1,'01–Sept. 30,'02	,,				,,	Wells	,,	750000000	4370	not given	not given	100	none	,,	yes	6 00	43000 00	9 84					493	,,			43000 00	9 84	
49	Covington	Ky.	42938	42938	Jan. 1,'02–Dec. 31,'02				,,	,,	Ohio R.	,,	926073652	5058	,, ,,	10801150	100	6-14 c. ,, ,, ,, ,,		no	6 00	68704 00	13 58			200 00		5061	,,		0 18	68904 06	13 76	1000 00 – 100 00
50	St. Johns	Can.	43048	43048	Jan. 1,'01–Dec. 31,'01	,,			,,	,,	Lake & River	,,	1398588000	5654	458143900	not given	3½			,,	10 00	52060 00	9 20	36000 00	2000 00			392	,,	none	6 73	90060 75	15 95	2739 85 [illegible] 320 1900 00 6[illegible]
51	Lancaster	Pa.	41459	45000	Mar. 1,'02–Feb. 28,'03	,,	,,			,,	Conestoga Creek	,,	2041235046	8500	not given	,, made	1		,,	,,	10 00	101000 00	11 80					543					11 [illegible]	1000 00 – 500 00
52	Holyoke	Mass.	43712	47043	Jan. 1,'02–Dec. 31,'02				,,	,,	Lakes & Rivers	,,	not given	3691	460111500	,, given	7	11¼-3¾		,,	none	101761 00	27 57		1637 35			576	8 00	4508 00	0 44	107907 15	28 01	5659 85 544 52 752 81
53	Spokane	Wash.	36848	50000	Dec. 1,'01–Dec. 1,'02	,,				,,	Spokane R.	,,	3168900000	12000	not given	50000000		11 ,, ,, ,, ,, ,,	,,	yes	10 00	142664 00	11 00					570	no	none		142664 00	11 90	
54	Yonkers	N.Y.	47931	52000	,, –Nov. 30,'02	,,	,,			,,	Springs	,,	1657439214	not given	880882333	50030922	100	15 ,, ,, ,, ,, ,,	,,	,,	4 00	117646 20	11 30					909	30 00	3660 00	4 91	141532 20	16 21	1263 01 266[illegible] 348 00
55	Duluth	Minn.	52969	60000	Jan. 1,'02–Jan. 1,'03	,,			,,	,,	L. Superior	,,	1652737000	4000	not given	none	65	5-25 ,, ,, 1000 gals		no	6 00	103000 00	25 75			2322 79		521			0 56	105322 79	26 33	936 01
56	Manchester	N.H.	56987	60000	Dec. 31,'01–Dec. 31,'02	,,			,,	,,	L. Massabesic	,,	1000000000	8000	,, ,,	not given	65	12¼ ,, ,, 100 cu ft	,,	yes	10 00	116000 00	19 45					768	25 00	19200 00	3 20	135200 00	22 53	2000 00 1500 00 [illegible]000 00
57	Springfield	Mass.	62059	64675	Dec. 1,'01–Nov. 31,'02				,,	,,	Impdg Rsvrs fed by Streams	,,	3029500000	10221	464341248	none	13	22-3 ,, ,, ,, ,, ,,		no	10 00	223903 00	21 90	none	21513 40	none		972	no	none	2 10	265416 40	[illegible]	1102 51 1023 70 837 50 6[illegible]
58	Salt Lake Cy	Utah	53531	65000	Jan. 1,'02–Dec. 31,'02	,,				,,	Mtn Streams	,,	not given	10000	not given	705900000	3	7½-2 ,, ,, ,, ,, ,,		,,	4 20	100000 00	10 00		792 00			1150			0 08	100792 00	24 00	2600 30 1443 20 970 00 535[illegible]
59	Somerville	Mass.	61643	65500	Jan. 1,'01–Dec. 31,'01	Part			Part	,,	Metropolitan H_2O System	,,		61643	354171716	64000000	2½	14-8 ,, ,, ,, ,, ,,		[illegible]	10 00	214000 00	16 33	,,				955	,,	,,		214000 00	16 33	1438 52 58 552 4959 60 5[illegible]
60	Lynn	,,	68573	73613	,, ,,		,,	,,		,,	3 Artificial ponds with River intakes	,,	1624680750	13000	100000000	100000000	25	13 ,, ,, ,, ,, ,,		yes	10 00	200000 00	15 30	,,				960	,,	,,		200000 00	15 38	1200 00 1000 00 400 00 200[illegible]
61	Wilmington	Del.	76508	80000	Jan. 1,'02–Dec. 31,'02		,,	,,		,,	Brandywine R.	Part	2694329025	7100	1336272000	3% of metered	1	3½-7½ ,, ,, ,, ,, ,,				175905 72	24 77	3063 68				805			0 43		25 20	8125 81 5070 24
62	Hartford	Conn.	79850	80000	Mar. 1,'01–Apr. 30,'02				yes	,,	6 Reservoirs	no		10000	2555000000	not given	95	12-6 ,, ,, ,, ,, ,,		no	5 00	250000 00	35 00	none				911	18 00	16398 00	1 84	266398 00	26 64	
63	Nashville	Tenn.	80863	80863	Jan. 1,'01–Jan. 1,'02				,,	,,	Cumberland R.	Part	248397971	8000	826976500	,, ,,	40	13-6 ,, ,, ,, ,, ,,		,,	8 00	158203 65	19 80	,,				703	no			158203 65	19 90	1000 00 800 00
64	Reading	Pa.	78961	81770	Apr. 1,'01–Apr. 2,'02				,,	,,	Spring Mtn Strms	no	2850644604	16842	1007909555	,, ,,	48	30-22 ,, ,, ,, ,, ,,		,,	none	166323 56	9 82		7173 97			760	,,		0 42	173497 53	10 24	880 65 3227 58 2347 80
65	Grand Rapids	Mich.	87565	90000	May 1,'01–Apr. 30,'02	yes	,,			,,	Grand R	,,	4240101003	13500	not given	10000000	20	5 ,, ,, ,, ,, ,,		,,	5 00	108000 00	8 00			300 00		1360	,,		0 12	108300 00	8 12	3000 00 – 200 00
66	Cambridge	Mass.	91886	95000	Dec. 1,'01–Dec. 1,'02	,,				,,	Brooks & Ponds	,,	2938353500	14000	840768200	189461675	13	15-7½ ,, ,, ,, ,, ,,	,,	yes	5 00	323500 00	27 07		3185 00			986	,,		0 22	326685 00	27 29	1469 00 826 50 394 00 3[illegible]
67	Richmond	Va.	85050	100000	Jan. 1,'02–Dec. 31,'02			,,		,,	James R.	,,	4105116135	12000	about 50%	not given	45			no		157835 61	13 15					640					13 15	500 00
68	Dayton	Ohio	85335	100000	,, –Dec. 31,'03	,,				,,	94 6in. Tube Wells	,,	2200000000	12500	8500	600000000					4 40	104000 00	8 32	3800 00	7000 00			1253			3 00		11 92	5000 00 – 500 00
69	Atlanta	Ga.	89872	100000	,, Dec. 31,'02	,,				,,	Chattahoochie R.	yes	2511687200	12000	about 50%	½ pumpage	100	8		on req'd	7 20	157000 00	13 08			200 00		1317			0 01		13 09	800 00 – 300 00
70	Albany	N.Y.	94151	100000	Oct. 1,'01–Sept. 31,'02	,,				,,	Hudson R.	⅔ Filt	4830336343	17604	750000000	not given	17	6-3¾ ,, ,, ,, ,, ,,		no	5 00	234870 42	13 34		2776 05	7478 11		842	,,		4 53	245025 58	17 07	3000 00
71	Fall River	Mass.	104863	108728	Jan. 1,'02–Dec. 31,'02		,,	,,		,,	Wattuppa L.	no	1593278921	7262	613291530	325117770	96	21-7½ ,, ,, ,, ,, ,,		,,	none	175859 95	24 13		4819 75			1031	,,		0 46	180676 74	24 81	457 82 195 79 157 54
72	Syracuse	N.Y.	108373	115000	Jan.,'02–Jan.,'03				,,	,,	Lakes	,,	1270000000	18000	9500000	none	50	14-3¾ ,, ,, ,, ,, ,,		,,	5 00	270000 00	15 00			2500 00		2780	,,		0 18	275500 00	13 10	300 00 – 900 00 per month
73	Seattle	Wash.	80671	120000	Jan. 1,'02–Dec. 31,'02		,,		,,	,,	Cedar R	,,	273961792	13000	,, ,,	not given	14			,,	24 00	303000 00	23 30		15000 00			803			1 13		24 43	1200 00 – 200 00
74	Los Angeles	Cal.	102479	125000	Nov. 1,'01–Nov. 3,'02				,,	,,	Los Angeles R.	,,	1750000000	27000	750000000	,, ,,	1500 meters	7	,,	yes	not given	502000 00	18 60					706	,,			502000 00	18 60	1300 00
75	Toledo	Ohio	131822	150000	Mar. 1,'01–Apr. 1,'02		,,			,,	Maumee R.	,,	3258914190	12500	not given	,, ,,	50	7½-2 ,, ,, ,, ,, ,,		no	6 00	150630 19	17 05			495 00		1153	,,		0 03	151125 19	12 03	1300 00 – 700 00
76	Rochester	N.Y.	162608	170000	Oct. 1,'01–Sept. 30,'02	,,			,,	,,	Lakes & Rivers	,,	5655472000	31700	2116000000	,, ,,	32	10½ 7½ ,, ,, ,, ,, ,,		,,	5 00	433000 00	13 65					2900	,,			433000 00	13 65	2 000 850 00 600 00 500 00
77	Providence	R.I.	175597	180000	Jan. 1,'02–Jan. 1,'03			,,		,,	Pawtucket R.	yes	4320411609	22758	no record	no free H_2O	82	15-12 ,, ,, ,, ,, ,,		,,	10 00	605307 35	26 00		31397 31			2052	,,		2 69	636704 66	28 65	3000 00 – 100 00
78	Kansas City	Mo.	163752	200000		,,				,,	Missouri R	no	5000000000	22088	can't estimate	can't est.	25	25-3 ,, ,, ,, ,, ,,		[illegible]	9 00	464398 72	21 02	19200 00	30000 00				,,		5 70	513598 72	26 72	100 00 – 700 00 per month
79	St. Paul	Minn.	163065	200000	Jan. 1,'02–Dec. 31,'02		,,		,,	,,	Lakes & Wells	,,	2881900000	16792	941453067	none	35	10-3 ,, ,, ,, ,, ,,		no	not given	202805 40	10 70					2387	30 00	71610 00	3 51	274415 30	14 51	
80	Minneapolis	,,	202718	225000	,, ,,	,,		,,		,,	Mississippi R.	,,	7000000000	22000	1370000000	1150000000	33⅓	8 ,,	,,	,,	4 00	240000 00	10 80					3300				240000 00	10 90	5000 00 – 500 00
81	Toronto	Can.		250000	,, ,,	,,		Surplus		,,	L. Ontario	,,	7993918325	40000	1230000000	none	3			yes	not given	311000 00	8 77	7000 00				4000	10 00	40000 00	1 75		10 54	
82	Montreal	,,	258730	258730	Jan. 1,'01–Dec. 31,'01	,,		yes		,,	St. Lawrence R	,,	7974057849	59000	826099673	no record		14-21				610536 00	13 73			none		1702	no			610536 00	13 73	2759 00 720 00 700 00 [illegible]
83	Milwaukee	Wis.	283515	300000	Jan. 1,'02–Jan. 1,'03	,,	,,			,,	L. Michigan	,,	9128941250	38000	4560403162	none	90	4½ ,, ,, ,, ,, ,,	,,	yes	none	451832 85	11 80	[illegible]	12633 00	15203 84	3303 48	2603	8 00	20824 16	3 54	559543 40	14 72	
84	Detroit	Mich.	285704	326178	July 1,'01–July 1,'02	,,				,,	St. Clair L.	,,	18335104706	70456	4374223218	3469720372	10	4½-½		,,	7 00	372985 76	5 28	75000 00	3338 03			3613	no		1 54	480355 79	6 8[illegible]	2258[illegible] 1696 59 1657 38
85	Cincinnati	Ohio	325902	339000	Jan. 1,'02–Dec. '02	,,				,,	Ohio R.	,,	15024200708	36629	3063723000	3800000000	6¾	8-6½		,,	none	787598 79	21 58	0.8	46619 58	10025 26		2730	,,		1 45	842343 63	23 [illegible]	2500 00 [illegible]
86	Buffalo	N.Y.	352387	375000	July 1,'01–June 30,'02	,,	,,			,,	Niagra R.	,,	43154825260	66560	4301709000	not given	2	4½-½ ,, ,, ,, ,, ,,		[illegible]	24 00	700000 00	10 54					4700	15 00	70500 00	1 07	773500 00	11 [illegible]	
87	Boston	Mass.	560892	600000	Feb. 1,'02–Jan. 31,'03	,,		,,		,,	Metropolitan H_2O Supply	,,	not given	106039	605638000	free city use	4¼	not given			15 00	2780358 00	21 10	13823 00	12801 93			7785			2 44		25 5[illegible]	
88	Chicago	Ill.	1698575	2000000	Jan. 1,'02–Dec. 31,'02	,,				,,	L. Michigan	,,	30892283020	211000	18000000000	not given	3	,, ,,				3500000 00	16 58										16 5[illegible]	5000 00 – 4000 00

KS STATISTICS

EIM, SUPERINTENDENT, MADISON, WIS.

A. D 1904

Total per	Amount rec'd from large Consumers	Rate	Annual operating Expenses	Kind of Fuel used	Price per ton	Price per cord	Miles of Main	No. of Valves	Price of Water Permits 5/8"	3/4"	1"	1½	regular	Service cost to Owner 5/8	3/4	1"	1½	regular	Kind of Service Pipe	Charge per ft. of main at Owner's expense	Owner of Meter	Meter Rent 5/8"	3/4"	1"	1½"	2"	regular	At whose expense Meters are repaired	Cost of Meter repair per annum	mtr	Total indebtedness	Rate of Int'st	Informant
[illegible]	$3500-6000	3.06 per 1000 gals		Ill. & Ia.	$3.00		4	24						$					lead	none	consumer	25% of meter cost						consumer's	$	$	$ 28000.00	5½	H.G. Hildebrand, Sup't
25	3000-8700	15 ,, 1000 ,,	3200.00	Soft Coal	6.95		14	36											wrt. i.	,,	city	19 ,, ,, ,,						owner's when frozen			65000.00	4	A.D. Cardwell, Clk of Bd
[illegible]	900.00 450.00 350.00	7-10 ,, 1000 ,,	7800.00	Run of mines Hocking	2.75		21	127												,,	Co	3.50-7.50						,, ,, ,,		0.15	175000.00	6	C.W. Wiles, Sec'y & Treas
544	275.00	6 ,, 1000 ,,	13000.00	Coal	3.25		15						3.00						lead	,,	city										20000.00	4	H.K. Bishop, Sup't
500	500-400.00	5 ,, 1000 ,,	11000.00	Natural gas			26							6.50 per service					galv. i.	,,	consumer	none						consumer's			153000.00	4	Geo. S. Callans ,,
1425	1196.36 684.36 900.00 800.00 750.00	4½-15 ,, ,, ,,	4229.64	Brazil Block Coal	3.45		15¼	91											lead	,,	city						2.00	city's		4.50	84000.00	6	Wm. F. Voss, Sec'y of Bd
	•		6000.00	Soft Coal & Wood	2.50	4.00	20	75						9.00-12.00 ,, ,,					wood	,,	Co.	,,						Co's, except when frozen					Don A. Salyer, Sup't
1303	603.33 397.44 206.02 200.00	6 ,, 100 cu. ft.	5831.45				33	259											galv i	,,	consumer							Co's		4.60	335000.00	4	Alex. Milne, ,,
169	1288.00 1447.00 1211.00 69.00	6-10 ,, 1000 gals	1675.00	Hocking lump	3.50		17	176						8.00 ,, ,,						,,	Co.	,,						,,		0.47	150000.00	6	E.A. Croll, Gen'l Mgr
2167	2250.14-472.14	3 ,, ,, ,,					21	196												,,	city							owner's					E. Ten Eyck Lansing, Cy Eng
1167	3000.00 1200.00 350.00 150.00	5-7 ,, 100 cu. ft.	12000.00	,, Valley	2.78		15	100					5.00						lead	,,	,,	,,						,, when frozen			46000.00	5	Wm. Andas, Sup't
151	1020.00 3000.00 2000.00	6 ,, 1000 gals		Soft Coal			29	200											,,	,,	,,							,, ,, ,,			37000.00	4	Chas. J. Anderson, Sup't
1159	500.00 250.00 125.00		10137.06	Shavings		1.65	25	173					4.00						,,	,,	,,	,,									90000.00	5	Henry Gross, ,,
1510	2558.45 442.69 314.26	7½ ,, 100 c. f.	6000.00				33½												cem. lined	,,	,, .						1.50	,, ,, ,,		0.20	229424.55	3½-4	Nelson E. Mather, ,,
1430	800.00 600.00	12½ ,, 1000 gals	12000.00	Soft Coal	4.25		54	423											lead 1	,,	,,							city's			69000.00	4	E.C. Preston, Commissioner
1900	•			,, ,,	2.35+		42											10.00	iron		Co.							Co's.			260500.00	5	A.K. Hale, Treas. & Mgr
2752	365.00 469.47 94.00	1¼ ,, 100 c. f	8884.65	Bituminous	4.07		37⅔	390											lead	,,	city	2.40	2.40	4.00	4.00			owner's, when frozen			538000.00	4	George A. Stacey, Sup't
1442	800.00 600.00 500.00	5½ ,, ,, ,,	15000.00				42	386											,,	,,	,,	none								5.00	300000.00	4½	J.J. Coykery, Cashier
5060	3600.00 3000.00 800.00 500.00	9-12½ ,, 1000 gals	16500.00	Bit lump	2.40 & 1.60		25	206	2.75	4.00	6.00									,,	consumer	0.50-1.00 per yr.						,,			348500.00	5-6	L.P. Andrews, Prest
659	2500.00 300.00	3¾ ,, 100 c. f	12000.00	Coal slack	0.88		27						1.00							,,	city	,,						city's	10.00		150000.00	4-5	S.B. Cartman, Sup't
1117	535.06 421.61 332.95	10 ,, 1000 gals	7382.71	None			31	268											iron	,,	,,							,,	208.85		287000.00	3.65-4	John C. Brosten, ,,
1537	2023.00 1200.00	4½ ,, 100 c f	7345.27				57⅔	366											lead	,,	,,	10% of meter cost						,,	306.84		501000.00	3	W.H. Richards, ,,
1325	2599.71 2188.35 958.00 762.00		3900.00				56												galv. i	,,	,,	none						,,	50.00		342000.00	3½	L.C. Wright, ,,
1378	573.50 558.45 465.20	10-15 ,, ,, ,,	22000.00	Bit.	4.625		39	652											,,	,,	,,	,,						owner's, when frozen			248000.00	4	F.H. Crandall, ,,
1374	3000.00 720.00 600.00	10 ,, 1000 gals	12000.00	Semi-Anth slack	0.75		32	167											lead	,,	consumer	,,											S.J. Rosamond, ,,
934	587.90 483.26 335.47 334.25	5 ,, 100 c.f	13551.69	Anth. pea	6.98		39	259				2.00							extra st. lead	,,	city						none	,, ,, ,,	90.00		20000.00	4½	John B. Heim, ,,
2422	2400.00 2000.00 750.00 500.00		42000.00	Slack	2.50		53	342											galv. i	,,	,,	,,						city's	25.00		321000.00	4½	Trustee Water Works
2515	5000.00 1400.00 1200.00 900.00	10 ,, ,, ,,	14500.00	Soft	6.46		40	533		2.50	3.00	4.00								,,	,,	,,						,,	103.59		none		F.A. Hoffman, Sup't
1389	4000.00 2500.00 2000.00	10 ,, 1000 gals	17000.00	,,	1.90		27	279											galv i	,,	consumer	,,						owner's			18000.00	5	Harry Rathroaf, Insp'r
960	527.70 481.10 312.00		12647.96	,,	2.30		50⅓	422		0.25 to 1.00									lead	,,	city	,,						city's		0.03	86000.00	5	R.R. Parkin, Sup't
357	3700.00 1430.00 1057.00 832.00	7-10 ,, ,, ,,	11324.76	Bit lump	3.50		40⅗	347											,,	,,	,,	15% of meter cost						both parties	481.67		67540.00	4-5	W.W. Bridgen, ,,
	8000.00 5000.00			,,	5.00		65	400												,,	Co	none						owner's when frozen					H.C. Holden, ,,
1965	1525.00 1120.00 715.00 650.00	13 ,, 100 c f	25000.00	,,	4.75		52	711								0.38 per ft.			iron	,,	city	,,						consumer's					L. Brown, ,,
	700.00 600.00 500.00 300.00	5 ,, ,, ,,	13176.00	Coal	2.10		53	433					2.50						lead	,,	consumer	,,						owner's			138000.00	4	W. R. Ries, ,,
1403	1400.00 1200.00 800.00 700.00		12000.00	None			45	198						8.00 per service					,, lined	,,	city	,,						,, when frozen			523000.00	3½	Thos H. Bennett, ,,
1115	550.00 530.00 420.00 360.00	5 ,, 1000 gals	13500.00	Bit slack	1.35		46	720					3.00							,,	,,	,,						city's		0.40	342000.00	4-8	E.L. Dunbar, ,,
1003			12000.00	Coal	2.20		59												lead	,,	,,	,,						,,		0.75	195000.00	3½-5	J.F. Harrison ,,
914	444.36 196.16 162.80	6-10 ,, 100 c.f	7791.31	Bit lump	2.90		46	685											extra st. lead	,,	consumer	,,						owner's	200.00		none		Geo. Houston, Comm'r
218	1200.00 750.00 737.00	10 ,, 1000 gals	54000.00				53	323											wrt. i.	,,	city	10% of meter cost						city's	50.00		526000.00	3½-4	P.J. Egan, Clk. of Bd
132	4500.00 1500.00 600.00 500.00	9 ,, 100 c f	27432.76	Bit	4.20+		79	570											tin lined	,,	consumer	none						owner's when frozen			591188.00	4	Geo. A. King, Sup't
143	2898.50	10 ,, 1000 gals	41568.71	,,	5.55		48	475											lead	,,	city	10% deposit for meter use						city's	571.83		732000.00	3-8	E.W. Kent, ,,
100	866.15 340.21 243.52		23000.00	,,	2.45		64⅔	691										16.00	lead	,,	,, & consumer	0.50						owner's		2.50	666000.00	4-5	Willis N. Calkins, ,,
1010	3600.00 2700.00	7 ,, ,, ,,	16000.00	Pittsburg & Va.	2.065		29	600					1.00	10.00 ,, ,,					,,	,,	consumer	none						city's	50.00		675000.00	.03-.065	W.L. Glazier, ,,
94	600.00 300.00		24000.00	Coal & Wood	2.75	1.50	97	810					1.00						iron	,,	city	,,						,,	16.00		550000.00	4½	M.F. Sullivan, ,,
	300.00		22000.00	Lump	2.10		36	363	4.50										lead	,,	consumer	,,						,,			50000.00	5	S.F. Tompkins, ,,
103	4800.00 1200.00 800.00 600.00	6 ,, ,, ,,		Ohio Coal	2.30+		63	466					3.00							,,	city	,,						,,			390000.00	4-5	R.A. Boyd, Sec'y
193	1695.93 1442.70 1381.00 551.91	1½ ,, 100 ,,	17687.48	Bit	5.15		74	917											cem lined	,,	,,	1.40						,,		1.13	845000.00	3¼	Horace Kingman, Sup't
94		15 ,, 1000 ,,	33000.00	Coal	2.04		58			2.00	to	5.00							lead	,,	,,	,,						consumer's			295000.00	4-4½	James Tyler, Comm'r
1574	1000.00-100.00	6-14 ,, 100 c f	37189.02	Soft, nut & slack	1.75		43½	628											,,	,,	,,	,,						city's			1190000.00	4	W.H. Glore, Sup't
159	2739.65 1113.20 1900.00 614.00		64848.07	None			72	1189											,,	⅓ of .01% of val	,,	10% of meter cost						,,			1373600.00	3	Wm. Murdoch, ,,
1102	1000.00-500.00	5 ,, 1000 gals	35764.77	Hard & Soft			57½	550	2.00	2.50																		owner's	200.00		400000.00	4-6	E.F. Frailey, ,,
280	5656.85 5447.52 792.81	3¾-11¼ ,, 100 c f	29643.39				83	792							14.00	16.00	21.00	25.00	galv i. lead lined	none	,,	1637.55						city's			300000.00	4	A.E. Pickup, Registrar
1102	•	15 ,, 1000 gals	16390.00	None			82	483						cost of labor					,,	,,	,,	none						,,			900000.00	5	F.P. Wynkoop, Prest of Bd
162	1263.01 2668.41 1248.00	5-12 ,, 100 c f	56354.39	Bit	3.50+		88	583				2.50 to 5.00							lead	,,	consumer	,,						owner's when frozen		2.00	1585000.00	3½-7	A.W. Kingsbury, Clerk
263	936.01	6¾ ,, ,, ,,	30961.36	Coal	3.00+		65	339								1.00			,, & iron	,,	,,	,,						,,			2051072.00	4 72/100	L.N. Case, Mgr
225	2000.00 1500.00 1000.00	12½ ,, ,, ,,	25000.00	,, partly	6.00	5.00	102	946											,, lined	,,	city	,,						city's		4.00	800000.00	4-5½	Arthur E. Stearns, Registrar
1008	1102.51 1023.70 837.50 644.60	5 ,, ,, ,,	23151.26	None			147	1983						owner's expense					galv. i	,,	consumer	,,						consumer's	200.00		1450000.00	5-8	A.R. Hathaway ,,
2490	2600.30 1440.20 970.00 832.00	3½ ,, 1000 gals	42150.00				153	1500					1.00						lead	0.75	city	,,						city's		3.00	250000.00	4½	Frank L. Hines, Sup't
163	14382.52 8818.32 4999.00 3963.60	6-12 ,, 100 c f.	20000.00	,,			88	1283						17.00 per service					iron, lead lined	none	,,	,,						,,			146000.00	4	Frank E. Merrill, ,,
153	1200.00 1000.00 400.00 200.00	15 ,, ,, ,,	75000.00	Soft Coal	5.00		132	980											lead lined	,,	consumer	,,						owner's		1.00	1500000.00	3½-5	D.A. Sutherland, ,,
252	5 258.01 8070.24		54339.40	Bit	3.15		109½												,,		city							city's			none	none	J.A. Bond, Chief Engr
206					.		130												iron	,,	,,	,,						owner's if neglected		1.00	675000.00	4	F.D. Berry, Sec'y
199	10000.00 8000.00	6 ,, ,, ,,	57829.00	Coal	1.84		80	927											lead	,,	,,	1.50						city's			1476000.00	4-6	John T. Ahearn, Sup't
1024	3306.51 3227.38 2347.80	22 6 ,, ,, ,,	38753.99	Anth & Bit	2.59		101	2295	2.00	2.00	3.00	5.00	7.50	owner's expense					,, & iron	0.50	,,	none						,,	281.17		400000.00	4	Emil A. Noebling, ,,
812	3000.00-2000.00	4-5 ,, ,, ,,	58000.00	Coal	3.00		164						2.50						,,	none	,,	2.00						,,			855000.00	3½-4	John C. Brown, Sec'y
2725	14469.00 8265.00 3914.00 3143.00	7½-15 ,, ,, ,,	62298.00	Bit	4.25		125							cost of labor					galv. iron	,,	,,	none						,,			2142964.00	3½-4	Walter H. Harding, Registrar
1318	500.00		36000.00	None			113												lead		,,							,,			undetermined	(	Chas. E. Bolling, Sup't
1192	5000.00-500.00		49000.00	Soft Coal	2.85		128	4000											,,		,,							,,	500.00		900000.00	3½-4	Chas E. Rowe, Sec'y
305	500.00-300.00	8 ,, ,, ,,	75000.00	,, ,,	2.34		131	1799										15.00	galv. i		,,						2.00	,,	176.93		1373000.00	3½-7	Park Woodward, Gen'l Mgr
1706	3000.00	6 ,, ,, ,,	112716.33	No. 2 Buck	2.53		132	862								1.00			lead	val iron 10% per yr	,,	none						,,			1511600.00	4	Robt Lockhart Sup't
248	4678.02 1957.81 1575.47	7-9 ,, ,, ,,	46957.70	Cumberland Bit	5.67		92	1020											,,	none	consumer	,,						owner's			2060000.00	4%	W.W. Robertson, Registrar
1511	300.00-900.00 per month	3½ ,, ,, ,,	40000.00	Coal	6.25		170	2900											,,	,,	,,	,,						,,		1.75	4100000.00	3½	Thos F. DaLacy, Sup't
244	200.00-200.00		50-60000.00	None			180⅓		2.00	10.00	12.00								ga.	cost	city	2.40	3.00	4.40		8.00		city's			2300000.00	5	L.B. Young, ,,
1060	2000.00	7 ,, ,, ,,	40000.00	Crude Oil			346							9.00	12.00	15.00				none	,,	none						,,			2000000.00	3¼	Wm. Mulholland, ,,
1206	307.80-700.00	3½ ,, 1000 gals	61137.76	Soft Coal	1.60		175	1268											lead	,,	consumer	,,						owner's if frozen		2.00	997000.00	4-4½	T.R. Cook, ,,
1345	2000 6500.00 6000.00 5000.00	10½ ,, 100 c.f.	115000.00	Bit	3.00		295	3100						cost					,,	,,	,,	,,						,,			5800000.00	3½	E.A. Fisher, Cy. Engr
2866	3000.00-1000.00	1½ ,, 100 gals	77922.69	,,	4.00	5.00	341												,,	,,	,,	,,						,,			6009000.00	3½-5	Robt. E. Smith Comm'r
2672	200.00-700.00 per month	4½ ,, ,, ,,	180000.00	Soft	1.35		220	1655						owner's expense						,,	,,	,,						,,			2903000.00	4½	Sam'l W Gregory, Cy Clk
145			50000.00	Youghiogheny	4.50		256	2210						,, ,,					,,	10% of taxes for 10 yrs	city	1.80-2.40						,, ,,			2386000.00	4-5	John Caulfield, Sec'y
1094	3000.00-500.00	8 ,, 1000 ,,	100000.00	Saw mill refuse	3.60		275	2000						,, ,,					,,	cost	consumer	none						city's			1800000.00	4	F T Moody, Registrar
1054			162346.00	Bit. Slack	3.09		264⅔	2452											,,		city							,,			3900000.00	4	R.J. Coady, Cy. Treas
137	2737.00 720.00 700.00 1000.00		139000.00	Soft	3.40		225	3037											,,	none	consumer	,,						owner's if neglected		1-3.00	9000000.00	4-7	Geo. Cupin, Sup't
1472			168238.17	Youghiogheny	2.90		370½	2414	5.00	6.00	8.00								,, extra st.	0.50	,,	2.00	2.00	4.00	4.00	8.00		,,	4200.00		482500.00	4-5	Chas J. Poetsch, Cy. Engr.
692	245.98 1698.49 1647.86	2½ ,, ,, ,,	124959.44	Bit. run of mine	2.31		581	7016		1.75	to	3.00							,,	none	city	none						city's		0.26	1029000.00	3½-7	H.S. Starker, Gen'l Mgr
228	2500.00 1800.00 1100.00	6½ ,, 100 c f	848294.36	Coal	1.40		427	8800											,,	,,	consumer	,,						,,		26.80	3775500.00	3-6	Wm H. Bode, Chief Engr
115			120000.00	Bit.	2.00+		495	7256						,,		,,			,,	,,	city	,,						,,			3701832.00	3½	Henry L. Lyon, Dist. Comm'r
254	•		742973.00				727⅓	9200										10.00	,,	,,	,,							,,		10.31	9501000.00	4½	W.E. Swan, Sec'y
1652	3000.00-4000.00		1017444.40	Maryland smokeless	2.87		1918	15437											,,	,,	consumer							owner's			50000.00		A.C. Nurse, Sup't

H. GARDNER, CHARTOGRAPHER.

rate first takes effect. There is no injustice done in either case. To assure the patrons of this fact, the face of the receipt is printed and filled out according to the consumption of water as illustrated above.

The reduction in rate reduced through the above scale brought our water rents from $14,127.91 January 1, 1903, to $11,972.03 at the rent day January 1, 1904. A loss of $2,155.88 in six months. At the same ratio for the next six months a loss of $4,311.76 for the year. The common council added the $10,000 to the tax levy for the benefit of the water fund, so that we are the gainer in the sum of $5,688.24 through the change.

There is never a change but with it comes a drawback, so it is in our case. We have a great many tenements used for boarding and lodging houses on account of the State university located in our city, with nearly 3,000 students. Under our previous rate the tenant in most instances paid the water rent. Under the new rate, the owner has to pay part of the rent in his taxes. Ninety-six per cent. of our population being water consumers, it was not unfair to collect under the old rate. But under the increase of our macadamized streets, we have 35 miles, and contracts let for three miles more, and a steady increase from year to year, which brings with it an increase of free water. Therefore, it is but meet and just, that a certain sum should be collected in the general tax for the benefit of this free water and placed into the water fund.

The summing up and conclusions arrived at by the examination of the statistics on the accompanying chart, proves to us, as we always believed, that a flat or uniform rate for all takers in a city, or a uniform rate for all water departments of the country, is an utter impossibility and an injustice to compel the same to be done.

The duties to perform, the expense to incur, the source of the water supply and method necessary to furnish the same to the consumer, the different resources of income, the locality, number of consumers, its indebtedness and requirement for a rapid growing city, all enter into the establishment of the meter rate of a well regulated water works system.

A system that receives its water by gravitation, or from a river or lake which requires no filtration can furnish water for less money than where filtration or double pumpage to store water is necessary, as in our case. A city with a large contingent fund and only large consumers metered, can sell water at a low uniform rate, as also such that have large resources, to make up the deficiency of the domestic consumers. Another city has to carry its water for miles before it is delivered to the consumer. In another city the variation of the price of fuel enters into the transaction. A municipality can sell water for a lesser rate than a company, because the city does not have to look for profits. If the rate is too low and it runs short a resource will be created to make up the deficiency. Again, if conditions were alike in New York City, Chicago, Philadelphia, Baltimore, St. Louis, Boston, Milwaukee, Detroit, Cleveland and Indianapolis, the greatest number of consumers would create the price. But as it is, each of the above cities must establish a rate to meet their requirements. One cannot be held up to adopt the same rate as the sister city. This same condition enters into all water departments.

Before concluding, let me call your attention to the decision of the Supreme Court of Wisconsin on the minimum water rate, showing the justice and need of such a rate.

Henry Vits, a resident of Manitowoc, Wis., refused to pay for more water than was actually used. The Manitowoc Water Works Company insisted upon collecting the minimum of $5 per annum, whether meter showed this amount of water used or not. The case was handed to the Circuit Court for decision. The court sustained Henry Vits. An appeal was taken by the water company to the State Supreme Court. The Supreme Court reversed the decision, sustaining the minimum charge.

The syllabus of the decision in The State, ex rel., Vits, respondent, vs. Manitowoc Water Works Company, Appellant, April 25-May 13, 1902, the court reversing the decision of the Circuit Court, reads as follows: "1.—A municipal ordinance granting a franchise to a water works company is not in case of ambiguity, to be construed most strongly against the company, but by the same rules that govern in the construction and interpretation of statutes. 2.—Such an ordinance fixed maximum rates which might be charged to private consumers for certain purposes, proportionate to the above, but the lowest annual rate in any case shall be five dollars. Manufacturing and special uses, rates to be based on quantity of water used. All parties have the privilege of furnishing water meter and paying only for water actually used at rates varying from 20 cents to 30 cents per 1,000 gallons, viz: consumption less than 1,000 gallons per day, 30 cents," etc. When the ordinance was enacted, meters for domestic consumers were comparatively unknown.

Held, That the provision relating to meters applied only to takers of water for manufacturing and special uses. and that the minimum for domestic purposes was five dollars."

My summary in the presentation of this paper is, that the best policy to pursue for both the water consumer and the water departments whether owned and controlled by a municipality or company, to follow the advise of the immortal Washington, the Father of our Country, "*To exercise at all times a sober and dispassionate judgment,*" in the meteing out and payment of the water rent. The motto should be, *"Live and let Live."*

THE EQUITY OF A MINIMUM CHARGE FOR METERED SERVICES.

By Frank C. Kimball,

Civil Engineer, Boston, Mass.

(Formerly Superintendent, Knoxville, Tenn.)

It may be taken for granted at the outset, that the practice of charging a minimum rate is universal wherever water is sold by meter, the only exception to this rule known to the writer being at Milwaukee, Wisconsin, where the only rate resembling a minimum charge is that of $1.00 per annum "for reading meters," as the rules say. This in itself is so near the line of a minimum charge that, unless there are other places, not known to the writer, it may be said that there are no exceptions to the rule. If there are a few places where no minimum rate is charged, they are so few in number that we may deduce, without further argument, the statement that a rule, practically so unanimously applied, would not have been adopted and would not have been allowed by the Courts to stand, unless it was in itself equitable and just. There is, however, probably no rule which superintendents and managers of waterworks are asked to explain the reason for, more often than this one, and it is for the purpose of giving the reasons which justify such a rule that this paper has been prepared.

To the question, "Why should I guarantee to the water department a certain fixed sum per year for the privilege of taking water from them, when I have a meter and am ready and willing to pay for all I use, any more than I should guarantee to the grocer or milkman to take a certain amount of their product per year or pay for it if I did not?" several answers will at once suggest themselves to the water purveyor, and while each may have their own reply, the one most firmly fixed in their minds, if not spoken, is that a minimum rate is necessary to produce the income required to meet fixed charges, operating and maintenance expenses.

The cost of supplying water to any community, unlike that of any other commodity offered for sale, depends not so much upon the quantity furnished,—within certain limits—as it does upon the cost of the pipes, machinery and other appurtenances necessary to utilize, prepare and properly distribute the water; the actual cost of the raw material,—in this case, water—being substantially nothing. From the moment, however, that work begins to render available, and to put into the individual houses and premises, a water supply under pressure, it begins to assume a value, based, however, not yet upon the value of the water itself, but upon the cost of obtaining and delivering it. This cost takes various forms; in some instances in the shape of damages for diversion of the water, formerly used for power or other purposes; in others, the expense of sinking wells to get to the water; and in still others, including also the above in some instances, the building of dams to impound it and carry it over the dry seasons; the cost of pumping stations with the necessary intakes, suction and discharge piping; pumping machinery; frequently the erection of a filtration plant and the building of reservoirs and standpipes for the purpose of storage and furnishing adequate pressure for proper distribution of water. In all plants, and in addition to all these or some combination of them, and constituting by far the larger part of the cost of a water plant, is the cost of furnishing and laying from such reservoirs, standpipes and other sources of supply, the necessary distribution system, ranging from one-third to three-quarters, and in some exceptional instances to seven-eighths the cost of the entire plant. These costs all have to be met before any water can be supplied to the consumer, and must be met, whether the quantity supplied be large or small; so that it can be readily seen that to this stage in the development of the plant, no rate, based upon the quantity of water actually used, could be depended upon to pay interest charges and depreciation upon the necessary plant, to say nothing of operating expenses, and this especially applies to a new community where the citizens are not fully educated to the use of a water supply under pressure.

For these reasons, amongst others, when water works are first installed in a city or town, it has grown to be the custom to charge fixed rates, based, not upon the quantity of water consumed so much as upon its convenience and availability to all the houses and premises along the lines of its mains. Later, as the uses of water develop, and the operating expenses, especially in works maintaining pumping stations and machinery, filtration plants, etc., increase somewhat proportionately to the amount of water used, it becomes advisable to meter the individual users of water, and to charge therefor upon a schedule based largely upon the quantity used; but even here very few departments can depart from the principle fixed at the beginning of the operation of the works, of charging a definite and fixed amount as a minimum for the use of water, to assist in meeting the large fixed charges of interest, depreciation and sinking fund requirements upon the entire plant, which charges bear no relation, within certain limits, to the quantity of water consumed; and it is for these reasons that minimum rates have been so firmly established as a part of meter rates in all water departments coming under the writer's knowledge.

As regards operating expenses, also, the quantity of water used bears very little relation to the cost of supplying it. This can readily be seen from the fact that where a pumping station with its machinery, etc., is required, it must be operated, and therefore manned, with the necessary salaried force for that purpose; and the only item of all the expenses connected with it that is or would be proportionately affected by the use of a greater or lesser supply of water to any taker during a given period, is that of fuel. Office expenses, repairs to mains, inspections, and the hundred and one other expenses go on just the same. Interest upon the cost of the plant that has been installed and must be maintained, continues for 365 days in the year, as do salaries, wages, taxes in a privately owned plant, repairs and all other items except fuel, and so also does depreciation, even though as a separate item this latter may not be shown on the books of the department.

This item of fuel is comparatively a small one when contrasted with the total outlay necessary in operating and maintaining a public water supply. The writer has had experience in the management of quite a number of plants situated in various parts of the country, and, varying with their locality and the cost of obtaining fuel, this item of expense in plants coming under his observation where steam pumping is required, ranges from about four per cent. to about fifteen per cent. of the total operating expenses and interest charges. Should sinking fund requirements and depreciation be taken into consideration, this per cent of the whole would be much less.

In the case of works where water power pumping is resorted to, or where the supply is by gravity, necessitating no pumping, the item of fuel is eliminated, and in that event the cost of supplying water within the limits of the plant as built and of the operating force required to manage it, is not varied by the amount of water used; and it is only when the use, and particularly the waste, of water obtains to a point where additional capacity and operating force are made necessary, that the charges for water can be equitably met by a charge in accordance with the quantity used, and even here the minimum rate is still necessary to properly distribute the cost in some degree to those receiving the benefits of the plant as a whole. Thus it can hardly be open to argument that, until at least his share of the general expenses have been met, no consumer is entitled to water at a specified rate per gallon, regardless of the amount used, and thus through extreme economy in the use of water, escape bearing his share of the burden of expense necessary in getting the water to him, before any delivery of it, even, is made.

As can be further seen, every house or premises situated along the line of water pipe has distinct advantages over those not so situated, and the privilege of being able to draw water at will is worth something and is an element of real value at all times. It aids in securing a lease for, and enhancing the value of every house, whether much or little water is used, and for purpose of charging each house taking water, some part of those costs of furnishing it which are apart from and bear no relation to the quantity used, the minimum rate, applicable to each house or premises, is established. Without this, in all places in the early part of their waterworks experience and, in nearly all places, during all of their waterworks life, it would be necessary to charge a very much higher rate than otherwise for water by measurement, and thus unfairly discriminate in favor of those who enjoy all the advantages of the water supply, although using very little water, and against larger users, who not only would pay the fixed charges applicable to the costs necessary to supply their own premises, but who also, without the application of a minimum rate, would contribute largely toward the fixed charges necessary to supply their fellow-citizens and neighbors.

As illustrating the above proposition, in one town in which the writer has had an extended experience, in the smaller or tenement class of houses, a real estate agent who controls something over five hundred tenements, stated that as between two houses exactly alike, one having a supply of water under pressure within the house, and the other with an ample water supply, but obtained from well or cistern, he could get from one to two dollars per month more for the house supplied with city water than for the other one; and as, for that class of houses in that city a rate for water of six dollars per year usually applied, it can readily be seen that the city water supply in effect increased the rental value of those houses from six to eighteen dollars per year over and above the water tax. Under these conditions, can it be said that such a supply did not enhance the value of this property, and, in doing so, that it was not just and right that they should in some manner, to at least a small minimum, be taxed to pay for that increase in valuation? This same real estate agent, as soon as he obtained control of property, had water at once put into such premises, if not already supplied, with the result that his property was at all times rented, while some of his less progressive competitors frequently had vacant houses on their hands.

In insisting that a minimum rate to an individual is unjust, it might as well be argued that a city or town, where an annual hydrant rental is paid the water department for fire purposes, should have such rental reduced each year, according to the length of time such hydrants were not in use, or that payment for such use should be made in proportion to the quantity of water used through them. While such a proposition would carry its own answer on its face, it is no more unreasonable than to expect a water plant to be built and operated without some return from the direct benefits conferred upon the property immediately affected by it. This principle is so thoroughly established that in a number of cities owning their own plants, it is provided for by charging a frontage tax against the property along which water pipes are laid, whether such property is built upon or not; while in some others, a water tax is charged against the premises, based upon valuation, and payment required whether water is used or not. If these forms of taxation for water supply are reasonable, how much more so is a minimum charge upon a metered service, which at the same time gives the consumer in volume of water, if desired, the full value of his payments?

Another feature coming under the parental care of cities and towns, and with which water supplies are closely identified, is the question of the health of the community. In this connection the use of water, like any other commodity, if paid for in accordance with the actual amount used, would, in spite of its comparative cheapness, be so carefully economized by some that not enough would be used for purposes of cleanliness and proper sanitation. As a proper health regulation, therefore, all citizens of a town or city should be furnished, either with or without price, an ample supply of water to meet these requirements, and no restrictions within those limits should be placed upon its use. Such use and absence of restrictions within the prescribed limits is best met by allowing every one their proper amount of water with a liberal excess limit to meet the requirements above stated, and upon the assumption that every water department, whether municipal or private, should be self-supporting, the allowance of a specified quantity of water to every citizen, carries with it, of necessity, the payment of a price in the shape of a minimum charge, sufficient to pay their pro rata share of the expense incurred in furnishing such water supply.

Before leaving this question, let us look to the legal *right* of the water departments to make such a charge. Since the last meeting of this Association, there have been two decisions of the highest Courts of the States that have come to the knowledge of the writer, where not only the minimum rate was sustained as being just and reasonable, but the further right of water departments to require each building or residence to be separately supplied, instead of being attached one to the other, and supplied through one meter. In October of 1903, at Knoxville, Tenn., in the case of Chavannes vs. the Knoxville Water Company, involving the right of the Water Company to charge a minimum rate for each house or premises attached to a meter, the Chancery Court of Appeals for the State of Tennessee, in an elaborate opinion, fully sustaining the contention of the company, used this language:

"We do not think it can be reasonably contended that it is not competent for the defendant company to charge a minimum rate and have a meter established upon each separate dwelling upon a separate lot."

It was further stated in this same opinion:

"We think it clear from the authorities, that the Company had a right to fix a fair and reasonable minimum charge for water supplied to any particular residence to compensate it for necessary expense and service of inspecting the meter and for water used not provided for by the contract. We think, therefore, that the rule of the company charging $10.00 per annum for each dwelling, store or other premises supplied thereby, and that only one such dwelling shall be attached to or supplied by one service pipe or meter, except by and with the consent of the water company and upon the written application of the owner that he will pay therefor not less than $10.00 per annum for each of the dwellings, stores or other premises so authorized to be supplied thereby, whether water to that amount shall be used or not, is reasonable and just where the dwellings are on different lots."

This opinion of the Chancery Court of Appeals was not accepted by the complainant in the case, and it was carried to the Supreme Court of the State of Tennessee on exceptions. The decree of this Court contains the following language:

——"the Court being of the opinion that the first rule attacked as to the minimum meter charge of $10.00 per annum for each dwelling, store or other premises supplied thereby, etc., is valid and reasonable, it is so ordered and decreed."

The full text of this case, with the decisions, was published in the Water and Gas Review for January, 1904, and has, therefore, probably come to the attention of most of the members of this Association.

Immediately following this case was another in Kentucky, decided by the Court of Appeals of that State on Jan. 22, 1904, in the case of Specht vs. Louisville Water Company, the syllabus of which is in the following language:

"A water company cannot be compelled to violate its regulations under which it furnishes water on the meter plan, but with reference to only one building or residence, by furnishing water to one consumer through one meter for his place of business, residence and four tenant cottages."

These are sufficient to show the leaning of the Courts upon this question, were it not for the fact that practice in itself establishes the rule, and consequently, its reasonableness, beyond question.

Mr. Benzenberg: I do not rise to question the propriety and justice of fixing a minimum rate. There is no doubt but what the custom generally prevailing in the establishment of a minimum rate, has been based upon just reason and good causes. What the minimum rate in each instance should be depends as much upon local conditions as it does in the case of regular rates, be they meter or flat rates. Each is so dependent upon local conditions that no two rates, of even any two similarly situated water plants can be accepted as always just to both.

I do, however, criticise the methods of the writer of one of the papers just read, used to justify his arguments for a minimum rate, or for the meter rate which he defends, by misquoting almost every condition and every statement with regard to one of the cities on his list, namely Milwaukee. I do not claim that he has done so intentionally, but he has been misled in every respect, and if the data have been taken from an annual report I do not see where he finds any justification for any of his statements. The amount of water Milwaukee is credited with as having pumped is just about one-half of that which it actually pumps. Instead of 4,500,000,000 odd gallons, it pumps 9,200,000,000 gallons. When the rate of revenue is based on any such statement as that, you are going to be led astray in your conclusions.

I wish to herewith submit an answer by the Registrar of the Water Department of Milwaukee. I am not now connected with that department, but would like to see the statements appear corrected upon our records.

ANSWER TO MR. J. B. HEIM'S PAPER, "METER RATES," BY THE REGISTRAR OF THE MILWAUKEE WATER DEPARTMENT.

The question of equitable water rates has been the subject of much controversy, during the past decade, in nearly every city in the country. It is a very important question, as it concerns such vast numbers of people, and for that reason each community ought to study the matter thoroughly, from every point of view, and then establish water rates in accordance with its best judgment.

My attention has been called to the paper on "Meter Rates," prepared by the Superintendent of Water Works, Madison, Wis., and published in the "Advance Copy" of the American Water Works Association.

As this gentleman has taken great pains to make a comparison of the revenues of the Madison with the Milwaukee Water Works; and as the figures he presents as representing statistics of the Milwaukee Department are grossly inaccurate, I am compelled to correct same, in justice to the American Water Works Association and all others who may be interested in the discussion of that matter. In this connection permit me to say that I deeply regret that the demands of my official position have not allowed me time enough to go more fully into the water rate question.

I believe, too, that Mr. Heim has unwittingly made the errors alluded to. To illustrate the fallacious conclusions arrived at in the comparison referred to, I shall quote the Madison gentleman's figures and statement as they appear on Page 3:

"Milwaukee's income from water rents was $431,832.95; from other sources it received as follows: Street sprinkling, $15,203.26; laying of water mains, $38,050.48; taps and branch permits, $12,633.00; hydrant rental, $20,824.14; from general city fund, $6,012.82; fire department, $782.75; police department, $392.00 and $1.00 each for reading 33,817 meters. A total of $127,715.45, or $3.36 per consumer. Total average per consumer of $14.72, against our $9.34; in favor of Milwaukee of $5.58. Milwaukee has any number of large takers and they pay as high as $37,000.00 per annum. We have only five large takers paying us from $325.26 to $587.90 per annum."

The alleged income, $431,832.95, is really nothing more than the total water rate assessment for 1902 less the sum of $1,563.96 assessed for the building permits (see page 261, Annual Report B. of P. W., 1902); but the said $431,832.95 *includes,* what Mr. Heim deceives himself in believing are other sources, street sprinkling, $15,203.26; hydrant rental, $20,824.00; police department, $392, and $33,817.00 for meter reading (see page 260, Annual Report, 1902). All deductions, therefore, made from the above premises must necessarily fail as erroneous and are of no value, as indeed, even were the figures correct, the comparison between the cost of water per consumer in Madison and Milwaukee is of little consequence, where it is conceded, as in this case, one consumer in Milwaukee uses more water than the entire annual pumpage of Madison. The purpose, however, Mr. Heim has in view is really to show that Milwaukee, notwithstanding its boasted low rate, receives on an average more per 100 cubic feet than Madison. He therefore seeks to add the receipts from construction, laying water mains, etc., as another source of yearly revenue which must be figured as increasing the water rate, although these are initial charges, from which the city derives no profit whatever, and besides they are collected from the taxpayer and can in no manner be considered as a burden on the consumer. His conclusions are (page 254) that Madison receives 8 cents per 100 cubic feet and Milwaukee "a trifle over 10¾ cents." How he arrives at these results is not entirely clear from the figures given; but one thing is certain; he is absolutely in error regarding the annual pumpage of Milwaukee for 1902, the year selected for the purpose of his inquiry. Mr. Heim figures as follows:

Milwaukee Annual Pumpage.....	4,560,403,162 gallons
Madison Annual Pumpage........	458,850,100 gallons

As a matter of fact, the annual pumpage of Milwaukee for the year 1902 was more than twice the amount stated, viz., 9,128,941,250 gallons. Consequently it is very plain that the average rate received by Milwaukee is less than one-half the amount stated by him if he used the pumpage as a basis for his estimates. I shall form a comparison with the Madison City Water Works for the year Mr. Heim has selected, and in doing so I shall disclose the entire receipts of Milwaukee Water Works for the year named, together with the figures he has given, of the Madison plant. The annual pumpage for 1902 was 9,128,941,250 gallons; entire receipts from all sources were $531,853.28; or $0.0436+ per 100 cubic feet. Madison's annual pumpage, according to Mr. Heim, was 458,850,100 gallons; entire receipts, $29,250.46; or $0.0478+ per 100 cubic feet; a difference of $0.0042+ per 100 cubic feet in favor of the latter city.

Mr. Heim is again mistaken in assuming that the charges for meter reading are not included in the quarterly water bills of which he presents a list taken from various Wisconsin newspapers as examples of Milwaukee's low water rates. Every one of these bills includes the charge for meter reading. The first is a bill for six months—200 cubic feet 9 cents and 50 cents for meter reading; total, $0.59; July quarter 1900. Second—3,500 cubic feet $1.58 and meter reading $0.25; total $1.83; January quarter 1902. Third—100 cubic feet $0.05 and meter reading $0.25; total $0.30; October quarter 1901. Fourth—400 cubic feet $0.18 and meter reading $0.25; total $0.43; January quarter 1901. Fifth—700 cubic feet $0.32 and meter reading $0.25; total $0.57; October quarter 1901. Sixth—1,100 cubic feet $0.50 and meter reading $0.25; total $0.75; January quarter 1902.

I might add that there are thousands of similar bills every quarter.

I believe, however, I have shown from the foregoing that Mr. Heim's deductions on the meter rate question, as far as they are based on comparisons with the Milwaukee Water Works system, are absolutely erroneous. I do not believe that gentleman has intentionally misconstrued the facts, but from his incredulous treatment and comments on the bona fide bills, which he has taken the pains to select as an evidence of bad faith on the part of some statisticians, I am constrained to regard him as unacquainted with the simple, equitable and satisfactory adjustment of the meter rate question as far as it applies to the city of Milwaukee. It cannot be expected, indeed, that Madison, situated as it is, a residence city, can sell water as cheaply as Milwaukee, one of the greatest manufacturing cities in the United States. Most of the water used in the former city goes for domestic purposes; while the latter city uses hundreds of millions of gallons for business purposes. The contention, however, that Madison is forced to use hard coal can hardly be sustained on the grounds named. Milwaukee's pumping stations are also located in resident districts; but by the use of Hawley Down Draft furnaces the smoke nuisance is eliminated.

In my opinion the flat rate as adopted in this city for meter charges, is the only just and equitable plan of assessment for measured water where the plant is owned by the city. Its simplicity alone is a sufficient recommendation. It is a matter of simple division. Divide the cost of maintenance by the annual pumpage.

To maintain that the large consumer is entitled to pay for water at a lower rate than the smaller consumer is no more reasonable than to declare that the large property owner ought to have a cheaper or lower rate of taxation.

It may be conceded that in small cities, where the cost of the delivery of water is great, it may not be expedient to adopt the flat rate. In such cases the city may be dependent on some large factory which uses vast quantities of water; and to insist on the matter of simple justice might be ruinous to all.

MR. BENZENBERG: I wish to state that though the Milwaukee Water Department is receiving some money from the police, park and fire departments and occasionally a credit for water furnished for street sprinkling and fire protection, yet I think in no instance has such amount exceeded $55,000 per year, notwithstanding which the revenue of the department has been sufficient so that the city council has diverted annually $100,000 of the water works fund back into the city fund; consequently, the credit it receives for fire hydrant rental, for sprinkling streets and for other purposes, is simply a book credit. This is returned and in addition thereto the water department has contributed $45,000 cash each year for general city purposes. The actual annual cash receipts for water, which according to the reports of the department have been received by the Water Registrar have not been over $385,000. Now, if their meter rate is fair and equitable for the citizens of Milwaukee, and fair, just and right to the water department, it does not necessarily follow that it is equally applicable as a fair rate in other cities. Milwaukee is fortunate in this condition, that where it has perhaps thousands of families not paying over $1 a year for water, aside from the $1 paid annually for reading the water meter monthly, yet its revenue is sufficient to pay all operating expenses, all expenses of maintenance, all of the cost of extensions, which are considerable every year, all of the interest on its indebtedness and 5% of that indebtedness each year, and of contributing, in addition to all of that, something like $50,000 to the general city fund for the purpose of reducing general taxation. The total bonded indebtedness of the Milwaukee water department is now less than $500,000, and in a few years it may perhaps be entirely wiped out. When that time arrives the City of Milwaukee will be able to again reduce its present low meter rate. Personally, I am in favor of some sort of a minimum rate, the amount of which, however, depends on local conditions. It is just as right, just as fair to give to the water department, whether it be operated by a private corporation or by the municipality, credit for the service that it does and is ready to furnish, as it is for a municipality to give credit to its fire department or its police department for what they stand ready to do. There is not a citizen who is asked to pay something more than for the small amount of water he actually uses who will not subscribe to the statement that a policeman is entitled to more time than that consumed in actually making arrests, or that a fire department employee should be paid for time other than that while in attendance on fires. Every citizen will admit that those employees should be justly and fairly paid for their time while employed in preparation for and while being in actual readiness to give the service that the community requires for the protection of life and property. Just in like manner is it fair that the water department should have credit and receive pay for the service which it stands ever ready to give to a community in the way of fire protection, or to give to an individual in furnishing a supply of water whenever he or they are ready or willing to draw upon it. (Applause). Whatever that amount may be, as I said before, depends altogether upon local conditions. I will not dwell upon that now, as it will be brought out further in the report of the Committee on A Standard Basis for Water Rates; but I do not think any one is justified in drawing or arriving at conclusions with unfair premises.

I concur with the sentiment of the paragraph with which Mr. Heim concludes his paper, that we should "exercise at all times a sober and dispassionate"—and I want to add to that—an unprejudiced "judgment."

Mr. Heim: Mr. President, I wish to state that it was not prejudice. I may have committed an error, I do not deny that; and I find on the map here the true statement given as to the amount of water pumped, which is as you can see on the diagram or chart, 9,128,941,250 gallons of water. I have got the document here. I expected probably questions would be raised and I have a statement here signed by the City Engineer of Milwaukee in which he places the annual pumpage at the last named figure; number of water takers, 38,000, and the amount passing through meters, 608,053,755 cubic feet; so that an error has crept in somewhere as to the amount of water pumped. How it occurred I cannot understand; it may be a typographical error which I did not discover. The number of hydrants given is 2,603, and this at the rate received from hydrant rental of $8 per hydrant annually, will figure out $20,824. as given in the statement. As far as the police department is concerned, or the others, the full amount of $127,715.50 I took from the items of the engineer's answer and the annual report, which should be correct. That is where your total income is obtained. Now my effort was simply to show the resources. I did not, and do not, want to bolster up anything. I just simply want to show that the resources were as the facts would appear. In Madison we have no resources that are derived from the hydrant rental, laying of water mains and service connections, sprinkling of streets or from any other source. The water mains and service connections are laid, and the meters furnished at the expense of the water department. This is not done in Milwaukee, there the plumbers sell the meters to the consumers, and the water department charges for laying service connections and mains to the property owner. The City of Milwaukee also charges a rental of $1 per annum for reading the meter as Brother Benzenberg stated.

The charge of $1 for reading the meter amounting to $33,817. and the other resources as enumerated in my paper foots up $127,715.50. All of this certainly assists them in selling their water for less money than a city that has no resources.

The City Engineer gave me, under his signature, the amount of water rents collected as $431,832.95 and that 90% of the water takers were metered, which means $33,817. The annual report, page 86, 1902, states: "Received from Water Registrar for water rates and meter repairs, $472,061.26," and the report of the Registrar on page 261 says: Amounts collected for meter repairs was $4,257.14, which would mean $35,971.17, instead of $33,817, or $2,154.17 more than my figures at 90%.

If you will add the water rents and resources together, I do not think that there will be any trouble in finding that they are receiving 10¾ cents, as against our 8 cents.

As to the statement of the charge of reading the meter on the bill and included in the 59 cents, I did not see the bill except as given in the papers. Milwaukee was quoted as an ideal city selling its water at 4½ cents a 100 cubic feet, and used as an illustration against our city by the parties as a pretext to create a disturbance. I wrote this paper for just that reason, which will also be published in Madison. It never occurred to me that with such small water bills as 59 or even 30 cents for three months, that that amount included the 25 cents for reading the meter. That would mean only 5 cents for three months water. Sheboygan and Appleton published these rates and they were spread broadcast. If there is some mistake in my figures I am willing to correct them most cheerfully. I give them as they were given to me under the signature of the City Engineer and as published in the annual report. I do not want to do an injustice to any one, and I do not want any injustice done to me. That is fair between us. So far as the pumpage is concerned, I do not know that it cuts much of a figure, as the amount that passed through the meters is given larger than the annual pumpage, and proves that there is a mistake, but the chart corrects that.

MR. BENZENBERG: I am ready and willing to go over the report with Mr. Heim. I have it here, and if he can show me where he gets the $127,745.45 additional to the water rates, I will put up any contribution to this association.

In regard to the revenue at 10¾ cents per 100 cubic feet, which he persists in stating is the correct rate of revenue at Milwaukee, I wish to state that it would have amounted to $1,308,481, as against the actual receipts of $384,468 during that year, or nearly three and one-half times greater.

MR. PATTON: I would like to ask Mr. Benzenberg what is his total investment from the beginning of the construction down to the present date of the water plant in Milwaukee; and how much of that investment is interest bearing charged up in the annual expenses; and how much of that investment is dead capital, which does not yield interest returns and on which there is no interest return charged up in the operating expenses of the plant?

MR. BENZENBERG: The operating and maintenance expense is and always has been paid out of the revenue. The works were originally constructed with funds derived from the sale of bonds. In the earlier years the extensions were made from funds derived from similar sources. The total bonded indebtedness amounted to over $3,000,000. The interest on the same has run from four to seven per cent., according to the time when the bonds were issued. The interest has been paid and nearly all of that bonded indebtedness has been redeemed out of the earnings of the water department; the constitution of the State of Wisconsin requiring that every municipality must retire five per cent. of its bonded indebtedness each year. The bonds to be retired are selected by lot and the total indebtedness is thus reduced each year by five per cent. The water department has in addition thereto paid for all extensions and has turned over to the general city fund, up to a year ago, some $657,000. Do I answer your question?

Mr. Patton: No, sir, the point I want to get at is, what is the total present investment in the plant, and what portion of that total amount invested is earning interest on the investment, which interest is charged up in the operating expenses; how much is the total investment on which there is no interest earned or calculated?

Mr. Benzenberg: The total bonded indebtedness upon which it did pay interest at one time was $3,000,000; but that has been gradually reduced by the revenue of the water department.

Mr. Patton: But the investment remains just the same. The point I want information on is, how much is the present investment on which there is no interest earned or calculated?

Mr. Benzenberg: The total investment to the present date is about $5,250,000.

Mr. Patton: Then there is over $4,000,000 on which no interest is calculated in the operating expenses?

Mr. Benzenberg: $482,000 is the total amount at present upon which interest is being paid.

Mr. Patton: Then I understand there is $4,768,000 on which there is no interest earned or charged in the operating expenses?

Mr. Benzenberg: The interest has been paid and the bonds representing the capital invested have been retired.

Mr. Patton: But still $4,768,000 of the original investment remains on which there is not a cent of interest paid, and yet you are basing a calculation on that condition for other people who have not got that four and one-half million dollars to sell water on?

Mr. Benzenberg: That is the condition at Milwaukee, a fortunate condition which I hope you will all attain in time, when you will not have to pay interest on any investment, but will have earned enough to have retired all of your bonds. I do not claim that the Milwaukee conditions are applicable to any other city.

SECRETARY DIVEN: It seems to me that Milwaukee has done pretty well; it has not only earned and paid interest on the cost of the works, but has also earned enough to pay off most of the original cost of the works, and having paid the money borrowed or raised to build the works I can see no reason why it should continue to pay interest on the original amount—which has been paid back out of the earnings of the plant. Mr. Patton's point does not seem to me to be well taken, it would seem to be a case of "eating the cake and having it" if they were to still earn and charge up in operating expenses interest on the money they have paid back out of earnings.

MR. KIMBALL: I think we all have had Milwaukee quoted to us—I know I have—a great many times, as being the place with rates upon which all rates should be based, especially by the consumer who is always looking for something for nothing. Now just to set the record right—Mr. Benzenberg understands my position, I think, just as well as I do—to set the record right and have something in print right from Mr. Benzenberg, if he will give it to us in answer to some of these questions, I would like to ask him this question: In comparing the water rates of other places with that of Milwaukee, would it not be fair and equitable for such purpose to figure interest upon the entire cost of the Milwaukee plant—simply for the sake of comparison?

MR. BENZENBERG: I may perhaps answer that question better if I might be permitted at this time to submit the report of the committee on the basis for rates, if that is permissible at this time.

MR. KIMBALL: Mr. President, my only point is this: As Mr. Benzenberg, in figuring the cost of water in his place, admits that he is figuring interest charges on only about half a million dollars, say, on a plant that cost ten times that amount, for the purpose of comparison with other places that are not in that excellent position that Milwaukee is, would it not be fair, for purpose of comparison only, that he multiply his interest charges by ten, and then see if the per cent. of profit might not be on the other side of the ledger?

MR. BENZENBERG: Mr. President, I think not, because I think the attempt to establish rates by comparison is an absolutely erroneous method.

MR. KIMBALL: I agree with you perfectly.

MR. BENZENBERG: And for that reason that should be discountenanced by every water works official, whether of a public or private company, for it is unreasonable to attempt to establish rates by comparison, because there are no two conditions alike as to any two cities.

PRESIDENT SHERRERD: The trouble is, you have to knock out the attempted comparison first and then start to apply a proper one. Milwaukee is always quoted.

MR. BENZENBERG: May I answer that by reading the report of the committee?

By unanimous consent Mr. Benzenberg, as chairman of the Committee on Standard for Water Rates, now submitted the report of said committee, viz.:

REPORT OF COMMITTEE ON STANDARD FOR WATER RATES.

To the American Water Works Association.

Gentlemen: At the last meeting of this Association at Detroit the matter of water rates was brought to your attention in a special paper upon that subject, which was thereafter pretty generally discussed by many of our members. The different opinions which were presented upon this subject plainly indicated that there had as yet been no clear, definite or concise basis formulated which would and should be the controlling element in establishing proper water rates in all cases or localities. This subject was therefore referred to a special committee to present such basis, if possible. It was also quite apparent that all speakers recognized the fact that no set of rates which might be fair and just at one place were for that reason necessarily right or reasonable for any other place, notwithstanding such opinion generally prevails among most water consumers and among those who, under the law, are vested with the power and authority to either fix or approve water rates. This general belief exists for the same reason that the idea is common that because a water supply has been successfully purified by a certain specific treatment, such treatment is equally suitable and will produce the same results with all other or even similar supplies. Both are fallacious.

The question of what are the necessary and essential elements that must be considered as constituting the basis for a fair and equitable rate for supplying consumers with water has been discussed at several of our conventions and also at the meetings of the New England Water Works Association, which latter at its annual meeting last January referred the matter also to a special committee.

Pure and wholesome water is one of the prime necessities of life and is also essential for personal comfort, cleanliness and sanitation, as well as for mechanical and industrial purposes. Its use is also indispensable to communities for the protection of health and property. The securing, maintaining and furnishing of an adequate supply of such water is therefore a business enterprise, pure and simple, whether undertaken by a private corporation under a franchise and contract, or supplied by the municipality under legislative authority. In fact, in cities which own water works, the department having charge thereof is, aside from municipal gas or electric plants, the only one which is engaged in procuring and selling a commodity, and therefore, to be run properly, should be operated only on a strictly business basis; in other words, it should be operated as an independent department, receiving no aid or support from any general tax levy, excepting that to which it is entitled for water furnished for the general good, like fire protection, street sprinkling, park, school or other public purposes, nor should the department be expected to furnish these services without such compensation or at the expense of the regular water consumers.

The conditions being, therefore, practically identical, excepting as hereafter noted, the basis for rates, i. e., the various items and accounts which the rates must be made to provide for, should be the same whether the ownership be municipal or private.

It is self-evident that the elements forming this basis should be in themselves so comprehensive as to be generally, if not uniformly, applicable, either in whole or in part, so that the rates will provide a revenue which will not prevent a loss during the first few years of operation, but which will be sufficient in from four to six years to cover this loss and justify the investment. If it were practicable to change the rates every few years, they might be fixed so as to materially reduce the loss at the beginning, but such rates would be burdensome and retard the natural increase in consumers.

Your Committee have not undertaken to discuss or report upon the merits of apportioning the rates upon a frontage, valuation, number of rooms, fixtures, consumers or meter, or any other plan, but have confined themselves to the consideration of the various items or elements of cost, for which the rates must be made sufficient to provide an annual equivalent. These elements will be taken up in their natural order.

First, the cost of construction. This item represents the original investment for which the annual income must provide a fair rate of interest. This item will differ in amount with every water works plant, depending upon the proximity, character and abundance of the supply, whether it requires pumping, storage and an expanded or contracted distribution system. These with many other construction features differ with each locality. Some plants must be constructed with a more generous capacity than others because of a more rapid growth, or because the locality is a manufacturing center, requiring water for industrial purposes. In each case, however, the local conditions being known, it is easy to determine the exact cost, and hence the amount of interest that must be provided for.

Second, the cost of operation. This item of continuous expense must naturally be included in the revenue from rates, and its amount will also vary with the conditions of each water works system, from one furnishing a supply of good water by gravity from an impounding reservoir in the hills, to one the supply of which must be filtered and pumped to several different elevations. This cost can also be arrived at without much difficulty when all the different requirements, together with the duty of engines and boilers, cost of fuel, oil, waste, of services in connection with the pumping, distributing, collecting and superintending is known.

Third, the cost of maintenance. By maintenance is meant those repairs and that supervision which are necessary to maintain the machinery, pipe system, buildings and all operating parts in good condition for efficient service, but not to the extent of replacing any unit element which constitutes a part of the water works system with a new unit element, nor such which as properly come under the head of "Extensions or Betterments."

It is somewhat difficult to determine definitely in a new plant what this amount should be in each case, excepting by comparison in a general way with the experiences of other similar plants. Mrch depends upon the character of the material and workmanship employed in construction, if cheap and inferior, the cost of maintenance will be relatively high ; if, however, it is high grade and first-class the cost of maintenance will be materially lower, though the cost of construction is thereby increased. In either case, however, there is an annual expense of maintenance, which must be paid for out of the revenue, and hence constitutes one of the elements which forms the basis for rates.

Fourth, the element of depreciation. Many of the various parts necessary to a complete water works system are more or less of a perishable character, while some other parts may be considered to be non-perishable. To the latter part belong well constructed reservoirs, dams and tunnels, also conduits, aqueducts, filters and foundations, if constructed of first-class masonry. To this may be added cast-iron pipe and special fittings if well coated and not subject to the action of electric currents. All other parts have a more or less limited period of service, due to their moving parts gradually wearing out, or due to a constant deterioration or because they become unserviceable, or no longer suitable for the service they were intended to furnish on account of inefficiency in capacity or economy, and for these several reasons require replacement or renewal at certain periods. Among these may be classed boilers, pumps, machinery in general, hydrants, valves, wood structures and cast-iron pipe and castings subject to electrolytic action from stray electric street railway currents. Unless the cost of renewing these parts at the end of their several periods of serviceability is provided for out of the earnings of the plant, the original investment will become depreciated and its value in the course of years greatly reduced. No capital would seek such investment, nor would it be good, sound business practice to permit such depreciation of the capital invested.

It is, therefore, necessary that the revenue be sufficient to permit a certain sum to be annually set aside as a sinking fund from which to pay for the renewals as they become necessary and thus maintain the plant constantly at a par value. This sum can be arrived at pretty closely when all of the existing conditions are known, by determining the life period and from that the element of annual depreciation of the several parts of the plant and setting aside annually for each such part a sum which at a fair rate of compound interest will at the end of the service or life period of such part, be sufficient to pay for its renewal.

These sums, however, do not provide for the renewal of any parts destroyed or injured by accident or the elements, nor for the payment of damages caused by such accidents or the carelessness of employees. Neither do they provide for depreciation due to faulty design, material or construction. There are perhaps very few, if any, water works in this country which have not at some time suffered relatively very heavy losses due to one or more of the above indicated causes.

There is another cause of depreciation which cannot be taken into account, and therefore be provided for, until the depreciation has occurred, namely, the polluting of a hitherto pure and satisfactory water supply, necessitating either the abandoning of such source of water supply, and frequently of the works adjacent thereto, and of constructing or developing a new, often remote, source of supply or of erecting and operating a purification works. This depreciation, in either case, necessitates an additional expense in construction and operation, which cannot always be met by an increase in the rates.

The basis, therefore, which must govern in determining the annual revenue to be produced by the rates charged for furnishing water service must contain the following elements:

First—The cost of construction.
Second—The cost of operation.
Third—The cost of maintenance.
Fourth—The depreciation.

To the latter should be added an annual amount to produce a limited reserve fund to be used for the replacement of parts destroyed by accidents or the elements. This is a reasonable provision, whether the works are owned by the community or a private corporation.

In the latter case, however, it is necessary to consider an additional element in establishing the basis for water rates, namely, the amount of the annual tax which is levied against the water works property, because this is as much a fixed charge in the case of such ownership as is the interest on the capital invested.

Another element to which your Committee desires to call your attention in the case of private ownership, arises where the franchise ordinance limits the franchise of the use of public streets, alleys and grounds to a definite term of years or where the contract for supplying water for municipal purposes is limited to a definite period without a guarantee of extending the franchise, or of continuing the contract upon a basis of fair and equitable rates or of purchasing such works at the end of such period at its true and actual value. Without such guarantee the value of the investment at the end of such period is liable to be wiped out and the property destroyed by a duplication of said entire works. In such case the owners are justified in protecting their investment by taking such contingency into consideration when fixing the basis for water rentals.

There are other items of expense, like that of litigation, which cannot be provided for in fixing a basis for water rates.

It is possible that some of these items may be properly anticipated at the time of fixing rates, but many of them are a matter of development and cannot be foreseen.

Your Committee, however, are of the opinion that no water rates can be considered as just, fair and adequate which do not take into consideration and provide for:—

1. A reasonable interest on the capital invested in the construction of the water works system.

2. The annual cost of operation.

3. The annual cost of maintenance as defined.

4. The annual amount necessary to provide a sinking fund from which to pay for the renewal of the several parts of the plant at the end of their respective periods of service.

5. The annual sum necessary to produce a limited reserve fund to be used for the replacement of parts destroyed by accidents or the elements.

6. A sum sufficient to pay the taxes, if any, and

7. Where the works are constructed under a limited franchise and contract period without a guarantee of a renewal of both or of the purchase of the plant at its actual value at the end of such period, an annual sum sufficient to produce a fund which will equal the actual value of the plant at the end of such period.

These elements, where they exist, are essential in the consideration of fixing or establishing water rates on a fair and equitable business basis.

G. H. BENZENBERG,
Chairman Committee.

PRESIDENT SHERRERD: Gentlemen, you have heard the report of the Committee. What is your pleasure?

MR. KIMBALL: Mr. President, this matter was up last year for discussion, and I took quite an active part in it. My point then was, as Mr. Benzenberg has stated very ably in his report, that no rates can be established in terms, but that certain considerations could be laid down which would lead to the proper establishment of those rates. This matter is one that I have had under consideration for the last two or three years, in fact, almost to the exclusion of everything else; and it seems to me that this report covers exactly what we are after. I would, therefore, move that the report be accepted and adopted by this Association.

Seconded by Mr. Heim and carried unanimously.

PRESIDENT SHERRERD: We have one other committee report that I would like to call up at this time, the Committee on Uniform Classification of Accounts, Mr. Dow R. Gwinn, chairman.

MR. GWINN: At the Detroit meeting of this Association a Committee on Uniform Accounts was appointed. I asked the secretary to see that my name was left off that committee. He responded by advising me that the President had made me chairman of that committee. I want to say that it is almost impossible to arrive at any method of accounting that will fully apply uniformly to all cities or to all water works plants. I doubt if this Association will ever be able to formulate such a plan. I have had some correspondence with the other members of the committee, Mr. Caulfield of St. Paul and Mr. Rowe of Dayton, and we have talked it over since arriving here. The consensus of opinion arrived at was that we would not be able to agree upon any uniform basis. However, we asked a number of water works companies and municipal water works departments to furnish us copies of their forms. We received quite a number. Mr. Rowe will tell you what he has received. I thought it might be well to submit the forms which I am using in connection with the Terre Haute plant, the result of about twenty-two years' experience in keeping accounts of water works, and in lieu of a more general report I will submit them:

NOTES ON FORMS USED BY THE TERRE HAUTE WATER WORKS CO., TERRE HAUTE, IND.

By Dow R. Gwinn,

PRESIDENT TERRE HAUTE WATER CO.

No. 1.—Application for Water. This form is printed on one side of sheet and 300 sheets are bound in one book. One is used for *every premises* that is to be connected with the mains. Each application is numbered and the number is a permanent one, the service being always known by the original application number. The application number is used for filing contract, permits, orders, etc., as will be shown further on. If a special contract is made, such as a meter contract or a three year contract, the original is either pasted over the form in the book or copy made of original or such information written on the form in the book as will readily show the character of the contract.

Our practice is to tap the main and lay the service pipe to the curb or service box, for which we charge $8 for either side of the street. This is for a service pipe not over ¾", usually of galvanized iron, and covers tapping, corporation cock with lead flange coupling, lead connection (if main service is iron), lead flange coupling, inverted key curb cock and Buffalo service box. We do not extend pipes into the cellar, but if a prospective consumer wants a yard hydrant we will put in about 27 feet ¾" galvanized iron pipe from the service box into the yard and furnish and connect a ¾"x4' Murdock pattern hydrant all complete for the sum of $6. We do not take the job by itself, but do it while the pipe is being laid to the curb.

No. 2.—Application for Water Through Meter. This form is printed on thin paper in loose sheets and, when signed, is pasted over the ordinary form in the application book.

The minimum annual rate of $12 applies to ⅝″ and ¾″ meters. The rate for 1″ meters being $2 per month and for 2″ meters the minimum is $5 per month.

No 1.
APPLICATION FOR WATER.

Application or Attachment No......

TERRE HAUTE, IND................190....

TO THE TERRE HAUTE WATER WORKS CO.

A supply of water is desired for the following purposes only at the premises No................ Street, for which......agree to use the water in accordance with your Rules and Regulations and to pay the schedule rates in advance as per the following rule:

When the rate includes sprinkling, one-half the sprinkling charge is payable April 1st and one-half July 1st at the office of the Water Works Company. All other charges are payable quarterly in advance at the office of the Water Works Company. If bill is not paid on or before the 10th day of the month when due, water may be shut off without notice.

......agree not to supply water to neighbors or allow them to take it, also that water will not be allowed to run to prevent freezing.

....Domestic or family use......rooms..........	......	......
....Additional families	......	......
....Bath.	......	......
....Water Closet	......	......
....Sprinkling..........feet	......	......
....Horses	......	......
....Steam Boiler for heating....................	......	......
....	......	......
....	......	......
....		
Total rate for.......................	......	......

......further agree to pay THE TERRE HAUTE WATER WORKS COMPANY the sum of $............ for laying the service pipe for............from the street water main to a point just inside the curb.

....

....

......corporation stop....pipe...............Licensed Plumber.
Additional fixtures ....
Send notice to...
Service, - $....Paid....19.. (Signature) ....
Plumbing, $....Paid....19.. (Owner, Tenant or Agent).......
Permit issued........190.. Water turned on............190..
" returned........190.. Entered in Ledger No............

SIZE OF ORIGINAL FORM 8½″ x 11″.

No. 2.

APPLICATION FOR WATER THROUGH METER.

Application No........

Terre Haute, Ind................190....

A supply of water is desired at the premises,

No.........................'.St.,

occupied as a........................., for which I agree to pay the ANNUAL MINIMUM RATE of TWLEVE DOLLARS for 40,000 gallons or less, and schedule rates for all water used in excess of 40,000 gallons. I hereby agree to give immediate notice at the office of the Terre Haute Water Works Co., upon removal from said premises, and that I will be responsible for water used until such notice is given; and that the officers and employees of the said Water Works Co., shall have free access (at reasonable hours) through my premises to their meter and to the pipe and fittings connected therewith.

If the meter gets out of order and fails to register, the consumer will be charged at the average daily consumption when in good order. No meter set for less than one year. The meter year is the calendar year. All accounts balanced Jan. 1st.

No deduction is made on account of leaks.

Every meter is tested by the makers, and also before leaving our office, but we will cheerfully test a meter in the presence of the consumer if he desires us to do so.

When a meter has been damaged by being frozen, or is injured through the carelessness of the consumer, he will be required to pay cost of repairs.

Meters must not be moved or repaired except by the employees of the Water Works Co.

......further agree to pay THE TERRE HAUTE WATER WORKS COMPANY the sum of $..........for laying the service pipe for........from the street water main to a point just inside the curb.

....

......corporation stop......pipe.....................Plumber
Fixtures ....
Guaranteed by ....
Deposited $.................
Send notice to..
......,...................Applicant

Permit issued........190 Water turned on.............190
" returned........190 Entered in Ledger No............

SIZE OF ORIGINAL FORM 6½″ x 9½″.

No. 3.—Agreement. For a period of several months in the spring we make a special offer to property owners, which provides for a free service to the curb if they will sign contract to take water and pay the rate for a period of three years.

This form is used in such cases. The uses, rate and memorandum are written on the form in the application book and the contract is filed.

No. 3.

Application No........

AGREEMENT.

In Consideration That the TERRE HAUTE WATER WORKS CO. furnish and lay at their own expense a service pipe from the street main to a point just inside the curb line in front of premises No...................street, the undersigned hereby agrees that...... will pay to the TERRE HAUTE WATER WORKS CO. the sum of.................Dollars per annum, quarterly in advance, for the period of three years for the privilege of using water at said premises for the following purposes only, viz.:

Domestic or family use......rooms..........	......	......
Additional families	......	......
Bath	......	......
Water Closet	......	......
Sprinkling	......	......
Horses	......	......
Cows	......	......
Steam boiler for heating....................	......	......
Store use	......	......
Office use	......	......
....	......	......
....	......	......
....	......	......
Total Rate for Year................	......	......

......Corporation stop......pipe. Additional fixtures..........

The charge for water will begin at the time said service pipe is laid to the curb by the TERRE HAUTE WATER WORKS CO. and water turned on to it. The subscriber agrees to use water and pay for the same in accordance with the rules of the TERRE HAUTE WATER WORKS CO.

Terre Haute, Ind...........190.. ....

Owner of said property.

Permit issued........190.. Water turned on............190..

" returned........190.. .... Plumber.

SIZE OF ORIGINAL FORM 7¼″ x 9″.

No. 4.—AGREEMENT. This form is used when residents of a block adjoining existing mains wish water service and cannot get the city officials to order a main. We extend mains where we can secure contracts for new business amounting to $50 per annum for three years per each block of 365′.

No. 4.

Application No ....

AGREEMENT.

IN CONSIDERATION That the TERRE HAUTE WATER WORKS CO. lay a water main, without unnecessary delay, upon .... Street, between ....and .... Streets, the undersigned hereby agree that.... he....will pay the said TERRE HAUTE WATER WORKS CO. the sum of..................Dollars per..............for the period of three years for the privilege of using water for the following purposes only at premises No................Street:

Domestic or family use......rooms..............	......	......
....Additional families	......	......
....Bath	......	......
....Water Closet	......	......
....Sprinkling ....6....	......	......
....Horses	......	......
....Cows	......	......
....Steam boiler for heating....................	......	......
Store use	......	......
Office use	......	......
....	......	......
....	......	......
Total rate for......................	......	......

......further agree to pay the TERRE HAUTE WATER WORKS CO. the sum of $...........for laying the service pipe for.............from the street water main to a point just inside the curb.

......corporation stop......pipe. Additional fixtures..........

The charge for water will begin at the time said water main is laid by the TERRE HAUTE WATER WORKS CO. and water turned on to it. The subscriber agrees to use water and pay for the same in accordance with the rules of the TERRE HAUTE WATER WORKS CO.

Terre Haute, Ind...........190.. ....

Permit issued........190.. Water turned on...........190..

" returned........190.. .... Plumber.

SIZE OF ORIGINAL FORM 7¼″ x 9½″.

No. 5.—Application for Water Annual Rate. This form is used where water has been off and the occupants of the house want it turned on. It is also used where rates are changed, showing rates and uses, and it is also an agreement to pay the rate for a year. Where water is used for domestic use, we do not turn it on for less than one year. However, if tenant should vacate property before the end of one year, the agreement is void.

No. 5.

APPLICATION FOR WATER—ANNUAL RATE.

A supply of water is desired for the following purposes only, at the premises No....................St., for which I agree to pay the rate for one year, quarterly in advance, and use the water as prescribed by the rules of The Terre Haute Water Works Co. I further agree not to supply or allow any person to use water from the service on my premises, and that I will immediately give notice at the office of The Terre Haute Water Works Co. when uses not included in this application are desired.

Domestic or family use......rooms..............	......	......
Additional families	......	......
Bath	......	......
Water Closet	......	......
Sprinkling .... feet	......	......
Horse	......	......
Cow	......	......
Store use	......	......
Office use	......	......
....	......	......
....	......	......
....	......	......
Total Annual Rate..........................	......	......

Send notice to..

..........................Applicant.

Terre Haute, Ind.....................190..

Permit issued for the following fixtures:

....

Plumber ....

Permit returned ....190..

SIZE OF ORIGINAL FORM 4″ x 8″.

No. 6.—Application for Water Through Meter. This form is used in the same way as No. 5, only it applies to services supplied through meters.

We ask for a deposit from parties who are not known to be financially responsible. We will accept a guarantee from the owner of the property instead of a cash deposit.

No. 6.

APPLICATION FOR WATER THROUGH METER.

Application No........

Terre Haute, Ind................190

A supply of water is desired at the premises, No.......................... Street, occupied as a.................., for which I agree to pay the ANNUAL MIMIMUM RATE of TWELVE DOLLARS for 40,000 gallons or less, and schedule rates for all water used in excess of 40,000 gallons. I hereby agree to give immediate notice at the office of the Terre Haute Water Works Co., upon removal from said premises, and that I will be responsible for water used until such notice is given; and that the officers and employees of the said Water Works Co. shall have free access (at reasonable hours) through my premises to their meter and to the pipes and fittings connected therewith.

If the meter gets out of order and fails to register, the consumer will be charged at the average daily consumption when in good order. No meter set for less than one year. The meter year is the calendar year. All accounts balanced Jan. 1st.

No deduction is made on account of leaks.

Every meter is tested by the makers, and also before leaving our office, but we will cheerfully test a meter in the presence of the consumer, if he desires us to do so.

When a meter has been damaged by being frozen, or is injured through the carelessness of the consumer, he will be required to pay cost of repairs.

Meters must not be moved or repaired except by the employees of the Water Works Co.

Guaranteed by ....

Deposited $..............

Send notice to..

.................................Applicant

SIZE OF ORIGINAL FORM 4″ x 8″.

No. 7.

APPLICATION FOR WATER FOR SPRINKLING.

A supply of water is desired for the following purposes only, at the premises No..........................St., for which I agree to pay the rate and use the water in accordance with the rules of The Terre Haute Water Works Co. I also agree not to supply or allow any person to use water from the service pipe on my premises, and that sprinkling will be confined to the frontage arranged for in this application and to one-half width of street.

EXTRACT FROM RULES.

No goose neck or other upright fixture will in any case be permitted to the sprinkling attachment without domestic charges. A street sprinkling permit authorizes sprinkling up to the center of the street, to the extent of the assessed width of the premises for which the sprinkling permit is granted. Under sprinkling permits the use of water is limited to sprinkling only, and the use of hand hose is limited to the hours from six to nine o'clock A. M., and from five to eight o'clock P. M., and is forbidden during a fire, unless for protection against such fire. No sprinkling is allowed in front of premises which do not pay the Water Company for such service. No nozzle larger than one-fourth of an inch is permitted to be used on hose. The use of hose without a nozzle, or as a substitute for a fountain, or allowing it to run while not being held by hand, is forbidden. Any use of a sprinkling attachment in excess of the foregoing limits is a violation of the terms of the permit, and a breach of the contract.

ORDINANCE ADOPTED BY THE CITY COUNCIL JUNE 11, 1875.

Use of Street Sprinklers.

Section 1. From and after any alarm of fire is sounded in said city, and until said fire is extinguished, it shall be unlawful for any person or persons to use or cause to be used in any manner, those certain water works fixtures known as "Street Sprinklers."

Penalty.

Section 2. Any person or persons violating the provisions of the foregoing section shall, upon conviction thereof, be fined in any sum not less than $1.00 nor more than $10.00 and costs, to be recovered in an action before the mayor of said city.

The sprinkling season begins April 1st and ends October 1st, in each year. No deduction from the season rate will be made if water is not used in the months of April and May.

The rate is payable in two installments, one-half on April 1st and one-half on July 1st.

Sprinkling .... feet	$..........
Horse	....
Cow	....
Total for Season....................	$..........

Send notice to..

....Applicant.

Terre Haute, Ind....................190..

SIZE OF ORIGINAL FORM 4″ x 8″.

No. 7—APPLICATION FOR WATER FOR SPRINKLING. This form is also used where service is already in premises and where water is desired for sprinkling purposes only. We turn water on about April 1st and shut it off November 1st. Under this special rate for sprinkling season we turn on the water the following spring to all premises that used water the previous season, unless notified to leave it off. If a premises has water connections and does not order water on previous to June 1st we charge the full rate; if ordered on about July 1st we make a reduction of 15%; August 1st, 40% reduction; September 1st, 70% reduction.

No. 8.—CONSUMERS' LEDGER. After working for years on separate books for flat rate and metered consumers, the writer hailed with pleasure a form used by Col. Donahue at Davenport. With a joint form of this character, the history of a service can easily be traced, for the records are on one account and show when the season rate was changed to an annual rate and also when a meter was set and charges began under that plan. Furthermore, and what is of great importance, the accounts can be usually found without referring to the index. For instance, supposing a city is on the bank of a river and the street running parallel with the river is First Street, the next Second, the next Third, and so on. In opening up a set of books I would enter the service farthest north on First Street as No. 1, the one next south would be No. 2, and continue south to the end of street or as far as there were services. I would then begin at the north end of Second Street and so on through the city. After the services on all streets parallel with the river had been entered, I would begin on the streets which run at right angles with the river. With this plan the bookkeeper soon learns the approximate location of the different streets and can easily find any of the old accounts. As new services are put in they are entered in the order of applications. When another set of books is opened the new accounts can be arranged in the streets where they belong.

The form adopted from the one used by Col. Donahue provided for meter collections every three months, but as we collect our annual bills quarterly and our meter bills monthly, I designed the form herewith submitted. If the service is on an annual basis, the rate for each use is entered to the right of item or privilege as shown under Inspection. The total rate is shown at the bottom where the word "Annual," "Season" or "Meter" is written. Whenever a bath, closet or additional use of any kind is added, a record with date of addition is made under the head of remarks; reduction and memoranda about contracts, date of later applications, etc., are also recorded. All payments are stamped with a rubber dating stamp which gives the book a uniform and neat appearance. With provisions for recording payments for service and plumbing, for expiration of contract and for location of corporation cock and service box, I believe the form is about complete. The great advantage is that by opening *one* book and turning to *one* account, most of the information about a service is available. With our system of filing papers and contracts pertaining to a service, the history of a service is available in the minimum amount of time.

This form is especially valuable where the tenants do not remain long in one house, for there are 16 lines that can be used if there were 16 tenants in the course of the four years. We write the date in small figures at the end or immediately under each name so that the record shows when each tenant began paying for water.

FORM 8, CONSUMERS' LEDGER.

(Size of page 18″x23″, two accounts to a page, divided vertically.) Each side is headed . . . . ; premises No. . . . . Street. Application No. . . . . . The left hand is headed "Inspection." Under this are entered the uses of water on the premises, as follows: Domestic user, Rooms, Bath, Water Closet, Horse, Heating Boiler, Store, Office, Sprinkling, Feet, then a few lines for miscellaneous use, and the total which is the "Rate." Opposite each of these is a dollars and cents column for the amounts.

The next column to the right is headed "Consumer," and is for the name of the consumer; the next two columns are for dates turned on or off and are headed respectively "On," "Off"; the next to the right comes the heading "Water Rent," with the sub-headings "From" and "To"; under these are the dates for the beginning and ending of the quarters—i. e., Jan. 1, April 1, the page being ruled for four years; on the right of these are columns headed "Inside Use," "Sprinkling," "Amount Due," "When Paid," each being ruled for dollars and cents.

Next below on this page is the space for meter rates; at the right are the months for the four years, then columns with unit rule headed as follows, from left to right: "Register," "Cubic Feet Consumed," "Gallons Consumed," "Value," "Amount Due," the last two having dollars and cents rule, and "When Paid," the column on the right is headed "Remarks," under which, in addition to space for general remarks is: "Minimum Rate," "Meter Set," "No," "Owned By," "Rate."

At the bottom of the page are lines marked as follows, viz.: The ...... Corporation stop in ...... St. Main is ......, the service box is .... The service pipe from main to curb is...........

No. 9.—Card Index. When an account is opened with a consumer, a card is added to our index, giving application number, street and house number, ledger number and name of consumer. There are enough lines to allow for future occupants of the premises. When we wish to look up an account, it is only necessary to know the street and house number. We have discontinued keeping a name index.

No. 10.—Document Envelope for Filing. This envelope is known as High Cut, Manilla Wove No. 12 XXXX. Every application number has a corresponding numbered envelope and into it are placed all contracts, plumbers' reports, inspectors' reports, made when water was turned on or off and papers pertaining to the history of the service. In order to get all the recorded information of a service, it is only necessary to look at the card index for the ledger number and application number. The former shows the account and with the latter the filing envelope can readily be found and in it all papers that have a bearing on the service. The first paper that is put in (if there was a special contract) is the contract, then the foreman's order giving locations and cost of laying pipe to curb, then the plumber's reports as they are made from time to time, then the order for turning on or off, the inspection reports, report when meter was set, etc., etc.

The idea is not an original one, but originated, as far as I know, with Mr. J. E. Sedgewick, Secretary Water Works Co., Waterloo, Iowa. I think it is a very valuable system for water works companies and departments. It is simple, comprehensive and a great labor saver.

The envelopes are filed in a vertical position in document files, about 100 to 125 envelopes being placed in each file. We use the "Elastic" Cabinet and get seven document files in each unit. As our business grows, we add another unit or section.

As stated before, the original application number is carried through the entire system, it is never changed. The ledger number will be changed with each new set of books, but the application number is always the same.

No. 11.—Service Order. This form is similar to a form I called "Plumbers' Permit" that I used where the service was laid from the main by the plumbers. I altered the Plumbers' Permit so that it would be adapted to our method here of having our men lay the service to the curb and sometimes into the yard. The information is entered in Consumers' Ledger and the order then filed under the application number.

No. 11.
SERVICE ORDER.
Order No.......... Application No.......... Ledger No..........
Date........................190..
Mr.. No..............................
Service from...................street main to...............................
....
Size of corporation cock............Size of pipe............Leave............
....

SERVICE ORDER.
TERRE HAUTE WATER WORKS CO.
Order No.......... Application No.......... Ledger No..........
Terre Haute, Ind......................190..
Mr.. No..............................
Service from...................street main to...............................
....
Size of corporation stock...........Size of pipe...........Leave...........
Plumber...................... TERRE HAUTE WATER WORKS CO.
Collect, $........... By.................................
REPORT.
The........corporation cock is..ft..in....of....prop. line of..............st.
and..ft..in....of....prop. line of....................st.
The....curb cock and service box are..ft..in..of..prop. line of..........st.
and..ft..in....of....prop. line of....................st.
The........inch street main is..ft..in....of....line of street.
The top of main is....ft....in. below surface of......................street.
Size and material of service pipe...
COST OF SERVICE TO CURB.
..feet Lead pipe, size....weight........@..............................$......
..feet of....inch Galvanized iron pipe, from main to curb cock..@.... ......
1..inch Corporation cock $..... 1..inch Curb cock $.., 1 Service box.. ......
1..inch Lead coupling, $...., Hauling $.......... ....
Labor, digging, etc., to curb..hours $.... Foreman.... hours $..... ......
..Yards street paving (see sketch other side).......................... ......
....

Total Cost service to curb............$......
COST OF PLUMBING.
..feet of....inch Galvanized iron pipe from curb cock to hydrant..@.. ....
Labor, digging, etc., from curb to hydrant....hours $............... ......
Hydrant with........nozzle.. ......

Total Cost plumbing............ ......
Water turned ....190.. Collected $......
Remarks: ....
....
....
....
....
Work done.........................190.. ....Foreman.
Entered by........ ....

SIZE OF ORIGINAL FORM 7½" x 13".

No. 12.—Extension Permit. This should really be called the "Plumbers' Permit." I have them printed in red ink in order to distinguish them at a glance from Service Orders. We require plumbers to return permits before water is turned on. The information is entered in Ledger and the report filed.

No. 13.—Inspectors' Orders. This form was designed to cover a variety of uses, but principally for turning on and shutting off water. The object in having the different items printed is to save time, as it is only necessary to check off the items which are most frequently used. There are several blank lines for special or unusual orders. The advantage in having a stub with a corresponding number is to check off the orders after they are returned, and then we can determine if any have been lost.

No. 14.—Annual Rate Bill. It will be seen that this form consists of a bill, coupon or stub and notice. After the bills have been made out and checked we send them to the printer, who cuts off the notices. These are delivered to the consumers, while the bills are kept in the office in a file so arranged that if the street and house number are given it is an easy matter to find the bill. We use the Addressograph for all annual and meter bills. The name, street address and number of account can be printed on the bill, coupon and notice in less time than it takes to tell it. The uses or privileges can be checked off instead of taking time to write them, so that it does not take long to make out our bills.

No. 15.—Meter Rate Bill. We have a number of consumers that use two meters, hence our bills are arranged for two sets of meter statements. There are advantages and disadvantages to this form.

Our plan is to present the meter bills, making one call only. If the bill is not paid on presentation, a notice is made out and left with the consumer, the bill being returned to the office. Note our offer to have meter state-

No. 12.

EXTENSION PERMIT.

No............

Application or Attachment No............

Terre Haute, Ind...... ....190....

M........................... No..........................

Plumber...... Meter?.... Additional Rate..... Total Rate.....

Extended From ....

Fixtures ....

....

..............................Leave water ....

....

OFFICE OF THE TERRE HAUTE WATER WORKS COMPANY.

No............

Application or Attachment No............

Terre Haute, Ind................190....

M........................... No........................

is permitted to employ......Licensed Plumber....to extend.....

service pipe from....................and connect the following fixtures, only: ....

.... Leave water ....

The Terre Haute Water Works Company.

Per...........................

PLUMBER'S REPORT.

The above service was extended from..............to supply the following fixtures:

..........................location..........................

.... " ....

.... " ....

.... " ....

.... " ....

.... " ....

.... " ....

.... " ....

Set............Meter, No..............to control..............

Shut Offs are provided..

Kind of pipe used..... Is extension supplied through meter?.....

Work done..................190.. Water left..............

See sketch of pipe laid underground by....on other side.

......certify the above to be a true and correct report of all plumbing done by........in connection with the water service on the above named premises.

....

Licensed Plumber.

The above work was inspected by........................190..

SIZE OF ORIGINAL FORM 7" x 12½".

BACK OF FORM NO. 12.

Line of Curbing.

Line of Street.

THIS SPACE FOR SKETCH OF PIPE.

Sketch of pipes laid underground in making the extension included in this permit. Mark the point where you began work or where connection was made with the original or old work with letter "A." Mark Risers "R" and Stop and Waste Cocks "S."

No. 13.

Application No...
Ledger No..190
Date. ....
M. ....St.
No. ....
Inspector. ....

(SEE ITEMS CHECKED.)

- ....Turn on at Service Box.
- ....Shut off at Service Box.
- ....Set Meter.
- ....Remove Meter.
- ....Repair Meter.
- ....Meter Statement.
- ....Inspect Service.
- ....Inspect Premises.
- ....Look for Leaks.

....
....
....
....
....
....
....
....
....
....

OFFICE THE TERRE HAUTE WATER WORKS CO.

Application No...................... Ledger No......................
Terre Haute, Ind.......................190
M.. No..........................St.

(SEE ITEMS CHECKED.)

....Turn on at Service Box.	....Shut off at Service Box.	....Inspect Service.
....Set Meter.	....Remove Meter.	....Inspect Premises.
Repair Meter.	Meter Statement.	Look for Leaks

....
....

INSPECTION.	REPORT IN DETAIL.
....Rooms	....
....Families	....
....Ft. Front..................	....
....Ft. on side................	....
....Closets	....
....Baths	....
....Faucets	....
....Basins	....
... Hose Bibs..................	....
....Hydrants	....
....St. Washers................	....
....Sill Cocks.................	....
....Horses	....

Date Executed.............190 Signature.......................................
Report location of fixtures and condition of same.

SIZE OF ORIGINAL FORM 9½" x 7".

No. 14

The only uses [illegible] are those which are checked [illegible] this list. Water must not be allowed to run to prevent freezing [illegible] are [illegible] water [illegible] or allow them to take it
When the rate [illegible] sprinkling one half of the sprinkling charge is payable April 1, and one half July 1

3000—N. Baltimore Glass Co.,
Sixteenth & Maple Ave

To THE TERRE HAUTE WATER WORKS CO. Dr.

For Water Rents from April 1, 1904, to July 1, 1904, for the uses checked in the following list, only:

Domestic Use	Rooms	Store	. . . . .Sprinkling
Bath		Office	. . . .
Water Closet		Horses	. . . .

[illegible] *Rate*, $ *Amount Due*, $. .

WATER RATES PAYABLE QUARTERLY IN ADVANCE. FOR RATES SEE BACK OF THIS BILL.

The water furnished is filtered at a great expense the standard of purity is high and we ask our patrons to co-operate with us in preventing waste, which cannot benefit any one and is a direct loss to us. We will put washers in faucets (including those at basins [illegible] bath tubs) free of charge, water closets and other fixtures must be repaired at the expense of the consumer.

3000—N. Baltimore Glass Co.
Sixteenth & Maple Ave

April 1, 1904, to July 1, 1904

Amount, $ . . . .

. . . .

ANNUAL RATE

PLEASE BRING THIS NOTICE WITH YOU

3000 N. Baltimore Glass Co.
Sixteenth & Maple Ave.

Your Water Bill, due APRIL 1, is as follows: For inside uses $

For Sprinkling $

Your Yearly Rate is $. Total, $

When the rate includes sprinkling, one half of sprinkling charge is payable April 1st, and one-half July 1st. All other charges payable quarterly.

This bill is payable at the office of the Company from the 1st to the 10th day of April. According to our new rules the supply may be discontinued if bill is not paid on or before April 10. Send check by mail if more convenient. We do not employ a collector.

If you have a faucet that is leaking, tell us and we will put in a washer free of charge.

If information is desired concerning your bill, please telephone No. 215 or call at the office as soon as this notice is received. DO NOT WAIT UNTIL THE 10TH.

It is the policy of this company to furnish the purest water and the best service, and to treat our customers as we would wish to be treated if we were the customers.

THE TERRE HAUTE WATER WORKS CO.
515 OHIO STREET Office Hours 8 A. M. to 6 P. M.

WATER RATES
OF THE
TERRE HAUTE WATER WORKS COMPANY.

GENERAL RATES.

[illegible]

RULES AND REGULATIONS.

[illegible]

[illegible] which do not pay the annual domestic rate. The sprinkling attachment must in all cases be a box, level with the ground in the yard. No goose neck or other upright fixtures will in any case be permitted to the sprinkling attachment without domestic charge. A street sprinkling permit authorizes the sprinkling of the sidewalk up to the center of the street, to the extent of the [illegible] width of the premises for which the sprinkling permit is granted. Under sprinkling permits the use of water is limited to such season for sprinkling only, and the use of hand hose is limited to the hours from six to nine o'clock a. m., and from five to eight o'clock p. m., and is forbidden during a fire, unless for protection against such fire. No sprinkling is allowed in front of premises which do not pay the Water Company for such service. No nozzle larger than one-fourth of an inch is permitted to be used on hose. The use of a hose without a nozzle, or as a substitute for a fountain, or allowing it to run while not being held in hand is forbidden. Any use of a sprinkling attachment in excess of the foregoing limits is a violation of the terms of the permit, and a breach of the contract.

XXVII. In no case will the Water Company be liable for damages by reason of shutting off any consumer while making repairs to mains or service pipes.

Ordinance Adopted by the City Council
June 11th, 1875.

USE OF STREET SPRINKLERS.

SECTION 1. From and after any alarm of fire is sounded in said city, and until said fire is extinguished, it shall be unlawful for any person or persons to use or cause to be used in any manner those certain Water Works fixtures known as "Street Sprinklers."

PENALTY.

SECTION 2. Any person or persons violating the provisions of the foregoing section shall upon conviction thereof, be fined in any sum not less than [illegible] nor more than [illegible] and costs, to be recovered in an action before the Mayor of said city.

PLUMBERS' RETURNS.

14. Plumbers shall make full and complete returns of the uses for and to which water is supplied under any permit granted. Said returns must be made by the plumber doing said work within forty eight (48) hours after the completion of said work, as the water will not be turned on any premises until after the return is made and the work reported to be in accordance with the rules and regulations therein prescribed.

PLUMBERS' PENALTIES.

15. Any plumber violating any of the Water Company's rules and regulations governing the introduction, supply and consumption of water, or who shall either voluntarily or at the request of any consumer or subscriber, introduce any hydrant, pipe, bath, water closet or [illegible] fixture which is prohibited by the Water Company, shall be prohibited from doing business either for himself or other plumbers in connection with the Water Company, and permit revoked and bond enforced.

This bill is rendered for the use of water as specified, and subject in all respects to the printed rules, regulations and rates of the Terre Haute Water Works Company, a copy of which is furnished, and which each consumer is requested to read carefully.

THE TERRE HAUTE WATER WORKS
COMPANY

In the original blanks these rules and rates are on back of bills

No. 15

METERED WATER BILLS ARE PAYABLE AT THE END OF EACH MONTH AT THE OFFICE OF THE WATER CO. PROMPT PAYMENT IS REQUESTED

No. . . . .

3408—Albrecht & Co.
518 Wabash Ave.

To THE TERRE HAUTE WATER WORKS CO. Dr.

Water Rent by Meter for the Month Ending . . .

Present Reading 00			
Last " 00			
Cubic Feet Used 00	X 7½ *Equal* .	. . . . *Gallons*, $.	
Present Reading 00			
Last " 00			
Cubic Feet Used 00	X 7½ *Equal* . . .	. . *Gallons*, $. .	
Minimum Rate, $ . . . . . . *per Month*		*Amount Due*, $. . . .	

IF INFORMATION IS DESIRED CONCERNING THIS BILL, please call Telephone No. 215, as soon as it is received. DO NOT WAIT UNTIL THE TENTH.
We try to avoid mistakes but when one is made will gladly correct it. Whenever requested to do so, we will have the reading of the meter taken again.
Every meter is tested before it is taken from the office, but if a customer doubts the accuracy of the meter on his service pipe, we will test it in his presence free of charge.

No. . . . .

3408—Albrecht & Co.
518 Wabash Ave.

METER BILL.
MONTH ENDING

. . . .

BRING THIS NOTICE WITH YOU

No.

M

Your water bill for month of 190

is $. . . . . *Gallons consumed*

Please pay at office No 515 Ohio Street, *on or before the 10th of the month.* Mail check if more convenient

Yours truly,

TERRE HAUTE WATER WORKS CO

RULES AND RATES

The minimum meter rate for small meters is $1.00 per month, or $12.00 per annum.
The calendar year is the meter year. No meter set for less than one year.
If the meter gets out of order and fails to register, the consumer will be charged at the average daily consumption, as shown by the meter when in order.
No deduction is made on account of leaks.
Meters owned by the Water Works Co. are kept in repair by said Company unless the damage to the meter is the result of the acts or carelessness of the consumer.
Meters must not be moved or repaired except by the employees of the Water Works Co. unless special permission is given by said Company to a Licensed Plumber.

METER RATES.

When the average consumption during any month is:

	1,000 gals.	or less, per	1,000 gallons	30c
Next	1,000 gals.	and less than	5,000 gallons.	20c
Next	5,000 gals.	and less than	10,000 gallons. .	15c
Next	10,000 gals.	and less than	20,000 gallons.	12½c
Next	20,000 gals.	and less than	25,000 gallons.	11c
Next	25,000 gals.	and less than	50,000 gallons. . . .	10c
Next	50,000 gals.	and less than	100,000 gallons.	9c
Next	100,000 gals.			8c

No. 16

M . . . . *No*. . . . .

No. . . . .

To TERRE HAUTE WATER WORKS CO. Dr.

For use of Water for Sprinkling. *feet*

Total amount for Season 190 $ *Amount due* $. . .

IMPORTANT.—This permit does not include water for family or household purposes, such as cooking and washing. THE USE OF HOSE MUST BE CONFINED TO THE FRONTAGE PAID FOR, and to one-half width of street. Sprinkling is not allowed between the hours of 9:00 A. M. and 5:00 P. M., or after 8:00 P. M. and is forbidden during a fire unless for protection against such fire. The use of a hose without a nozzle or as a substitute for a fountain or allowing it to run while not being held in hand is forbidden.

Season Rates are payable in two installments, one-half on April 1st and one-half July 1st. There is no reduction in Season Rates where water is not used in months of April and May.

No. . . . .

M . . . .

No. . . . .

. . . .*Installment on Season Rate*

190

$. . . . .

No. . . . .

M. . . . .

No. . . . .

The. . . . .*Installment now due on rate for*
Sprinkling is . . . . $ . . . .
Total Rate for Season $ . . . .

This amount is payable at the office of the company. According to our new rules the supply may be discontinued if bill is not paid in 10 days. Send check by mail if more convenient.

Season Rates are payable in two installments, one-half on April 1st, and one-half July 1st. There is no reduction in Season Rates where water is not used in months of April and May.

If information is desired concerning the bill, please telephone No. 215 or call at the office as soon as this notice is received. Do not wait until the tenth day. If there is an error we will gladly correct it.

Where water is taken the entire year for domestic use we give a lower rate for sprinkling. It has been shown that all the cases of Typhoid Fever were among people who use well and cistern water. You cannot afford to take the chances when you can get a supply of pure whole some water for two cents or less per day. The domestic rate for a six room house is only $5.00 per annum, payable in four installments of $1.25 each. Where water is used for sprinkling, the additional rate for domestic use in a six room house for the year is $3.50.

THE TERRE HAUTE WATER WORKS CO
No. 515 OHIO ST. Office Hours, 8 A. M. to 6 P. M.

PLEASE BRING THIS NOTICE WITH YOU.

ment taken the second time; also to test meter in presence of consumer, free of charge. As we test all meters before setting them and have confidence in their accuracy, we stipulate that the consumer shall see the test if it is made at his request.

No. 16.—SEASON RATE BILL. We have over 400 consumers that use water during the season when sprinkling is necessary. The rate is payable in installments, one-half in April and one-half in July.

No. 17.—DELINQUENT NOTICE. We usually call this our "Black Notice" to distinguish it from the second delinquent notice, which is printed in red ink. These notices are mailed as soon after the 10th of the month as possible. The present form has been arranged to be used in Outlook Envelopes, thus making it unnecessary to address the envelope, as the address on the notice shows through transparent paper attached to the envelope. We intend to arrange all our notices in the future so that they can be used in Outlook Envelopes, as their use saves a great deal of time.

No. 17.

OFFICE TERRE HAUTE WATER WORKS CO.

TERRE HAUTE, IND....................

....

....

The water rate on your premises was due and payable on the 1st inst. According to our new rules all bills are payable at our office, No. 513 Ohio Street, not later than the Tenth of the month when bills are due.

The amount of your bill is $...............................

Send check by mail if more convenient.

Trusting that you will give this matter your earliest attention, we are,

Yours respectfully,

The Terre Haute Water Works Co.

If you have a faucet that is leaking, tell us and we will put in a washer free of charge.

SIZE OF ORIGINAL FORM 4″ x 6″.

No. 18.—Second Delinquent Notice. This form is printed with red ink and is commonly called "Red Notice." These are mailed to delinquents who did not pay attention to the "Black" or first delinquent notice. They are usually mailed about five (5) days to a week after the "Black Notices" were sent, but we send them as first delinquent notice to unreliable and slow-pay consumers. In order that we may know when notices were sent to consumers, we stamp the date in black ink on the bill when the first notice is sent and the date in red ink when the second notice is mailed.

In three or four days from date the red notices were mailed we give a list of them to our inspector and start him out with orders to shut off the service unless satisfactory arrangements are made.

No. 18.

OFFICE

THE TERRE HAUTE WATER WORKS CO.

Terre Haute, Ind...................

....

The water bill, $................on your premises No........................is still unpaid. *If you wish the supply continued* please send amount immediately to our office, No. 515 Ohio Street. Mail check if more convenient.

We are furnishing water of unusual purity, and strive to make the service as near perfection as intelligence, labor and money can make it. Our expenses are very high, and as our revenue is made up largely of small amounts, it is necessary to have prompt payment from each customer in order to meet our obligations.

When water is shut off for non-payment of rent, it will not be turned on again until all back rents and $1.00, the expense of turning off and on, has been paid.

We want your business and hope we may continue to serve you.

Yours respectfully,

THE TERRE HAUTE WATER WORKS CO.

SIZE OF ORIGINAL FORM 4″ x 6½″.

No. 19.—DAILY CASH RECEIPTS. This form is bound in a book containing 500 pages, into it are entered all receipts of every character. The head lines as shown represent about every head under which money is received. Under the head "Material" we enter receipts for sale of scrap iron or anything about the plant that may be sold.

Ordinarily the receipts for the day will cover a number of pages and the amounts are carried forward. The totals under each head are entered each day into our General or Main Cash Book. As only the totals are posted, it does not take much time. Then from the main cash book the items are posted into the ledger, where there are accounts for each head. We have used this form for some time and find it very convenient.

FORM NO. 19. DAILY CASH RECEIPTS.

(Size of page 13½"x16½".)

First left hand column headed "No." next "Name," next "From" and "To." The next eight columns being headed respectively Annual Rates, Meter Rates, Season Rates, Miscellaneous Revenue, Services, Plumbing, Material, Meter Deposit.

FORM 21. RECORD OF METER TO BE SET.

This form is printed on an express or address tag 3"x 6¼".

RECORD OF METER TO BE SET.

TERRE HAUTE, IND., 190 .

Mr. ....

No. .... Street.

Plumber. ....

Meter. ....

No. ....Register. ....

Test ½ in..........⅛ in..........1-16 in..........

....

Perforated and lower half printed the same.

FORM 22. INSPECTORS' AUTHORITY.

TO WATER CONSUMERS.

The bearer is our authorized agent and visits your premises to make an inspection of the uses of water thereon and the condition of the water fixtures in order that our records may be complete.

We request that you will facilitate this business, and hope that it will cause you no inconvenience. The inspection is made in accordance with our rules, as follows:

"The Superintendent and proper officers of the Company shall have access, at all reasonable hours, to all parts of the premises to which water is supplied to make the necessary examinations." Yours truly,

THE TERRE HAUTE WATER WORKS COMPANY.

No............

Date.. 19....

Name. ....

No. ....Street.

Water to be taken from...

....

Owner of property..

Brick Contractor...

Plastering " ....

Stone " ....

Kind of Building...

ESTIMATE.

........M. Brick @ 10c, $........

........Yds. Plastering

........Perch Stone @ 7c, ...

........Yds. Concrete ....

Paid.......................... .... $........

FINAL SETTLEMENT.

Date...............................

ACTUAL MATERIAL USED.

........M. Brick.............................. ..... $........

........Yds. Plastering.............................. ....

........Perch Stone.............................. ....

........Yds. Concrete.............................. ....

$........

Rebate given.............................. $........

Excess paid.............................. $........

No. 20.

KEEP THIS PERMIT ON THE JOB, SO THAT IT CAN BE SHOWN TO THE INSPECTOR WHEN HE CALLS.

BILL AND PERMIT FOR BUILDING PURPOSES.

No...... Office of the TERRE HAUTE WATER WORKS CO.

Terre Haute, Ind.,......................19....

M............................ permitted to use water from........................

........for the following purposes only, at No............................Street.

........M. Brick..............................10 Cents per M, $...........

........Yds. Plastering........................10 " per 100 Yd. $...........

........Perch Stone............................ 7 " per Perch ....

........Yds. Concrete.......................... " per Yd. $...........

Received $.......... on account of the above. $...........

THE TERRE HAUTE WATER WORKS COMPANY.

By..

Charges used for water for building purposes are payable in advance. Where water is wanted for building purposes in small dwellings a minimum charge of $2.00 will be made when it is necessary to turn on water. The contractor should furnish evidence, such as estimate of work, bills for material or architect's certificate when applying for permit or after work is completed.

The Water Works Co. may have the work remeasured by an inspector, and in case it should appear that the person receiving this permit has made misrepresentations as to the amount of work done under the same, no water will be furnished to him for any other buildings until the bill for additional use of water, and the charge for inspection, has been paid.

FINAL SETTLEMENT.

Actual Material Used:

........M. Brick.............. $........

........Yds. Plastering....... ....

........Perch Stone........... ....

........Yds. Concrete......... ....

$........

Rebate given.................. $........

Excess paid.................. ....

Date ....

SIZE OF ORIGINAL FORM 11½" x 6".

No. 20.—Bill and Permit for Building Purposes. This form is used where water is desired for building purposes or special purposes, such as flushing sewers, etc. Our plan is to charge a contractor 50% extra if we find him using water without a permit.

No. 23.
PLUMBERS'S BOND
THE TERRE HAUTE WATER WORKS CO.
Terre Haute, Ind.

KNOW ALL MEN BY THESE PRESENTS, That we.. are held and firmly bound unto The Terre Haute Water Works Company in the sum of One Thousand Dollars, lawful money of the United States of America, to be paid to The Terre Haute Water Works Company, its successors and assigns; for which payment well and truly to be made, we bind ourselves, our heirs, executors and administrators firmly by these presents.

Sealed with our seals and dated this....day of..............A. D. 19...

WHEREAS, The above named...carrying on the business of Plumber in the City of Terre Haute under the firm name of.. and desire a license to do plumbing work in connection with the water works system of The Terre Haute Water Works Company.

NOW, THE CONDITION OF THE ABOVE OBLIGATION IS SUCH, That if the said...shall indemnify and save harmless The Terre Haute Water Works Company of and from all accidents and damage consequent upon or by reason of any opening in any Street, Lane, Alley, Avenue or Public Grounds in said City, made by..or those in........employment, for the purpose of putting down any service pipe or pipes, or other fixtures for the introduction of water, or for repairs of any service pipe, service box or fixtures used in connection with service pipes, or in consequence of the improper replacements of pavements, gravel, earth, or other material in said openings made for the introduction, extension or repairs of water pipes; and if the said .... shall faithfully and truly comply with all the rules and regulations which have been established by The Terre Haute Water Works Company for the government of Plumbers, and..........or..........employees shall not make any connection or extension to the water pipes of said Company without first receiving a written permit so to do, and shall make a full and correct report on said permit of all connections, extensions and fixtures or apparatus which..........ha....made or put in.

And if the said.. shall well and truly pay, or cause to be paid, any judgment, damages and costs that may be recovered against The Terre Haute Water Works Company, by reason of the negligence of the said..or any of........agents or employees, or in consequence of any act done by the said.................................... or any of.............agents or employees, then this obligation to be void and of no effect; otherwise, to remain and be in full force and virtue in law.

..................................(SEAL)
..................................(SEAL)
..................................(SEAL)
..................................(SEAL)

Signed and delivered in presence of
....
....

SIZE OF ORIGINAL FORM 7½" x 12½".

No. 21.—Record of Meter to be Set. This tag is perforated. It is tied to the meter as soon as tested and the record of test made. Before the meter is sent out, the form is filled in, showing name, address, name of meter, number, etc., in duplicate. We tear off the lower portion for our record, and the upper part remains on the meter so that if a number of meters are being set at one time, there is no danger of getting them mixed.

No. 22.—INSPECTORS' AUTHORITY. These cards are used by our inspectors.

No. 23.—PLUMBERS' BOND.

No. 24.—PLUMBERS' LICENSE.

No. 24.

PLUMBER'S LICENSE.

THIS IS TO CERTIFY that

....

having given a bond of One Thousand Dollars are hereby licensed to do plumbing work in connection with the Terre Haute Water Works Company, in accordance with the Plumbers' Rules of said Company, from this date to December 31st, A. D. 19..

Terre Haute Water Works Co.

....	....
President.	Secretary.

TERRE HAUTE, IND....................19..

All Plumber's Licenses expire by limitation on December 31st of each year.

SIZE OF ORIGINAL FORM 6½" x 5½".

No. 25.—REBATE RECEIPT. When a consumer orders water off, a rebate for the unexpired term of payment is given.

No. 26.—METER RATE REBATE CHECK. This form is used in equalizing minimum rate at the end of the year.

No. 27.—WEEKLY PAY ROLL. The numbered headings represent different kinds of work.

No. 28.—VOUCHER. A receipt is taken for every payment made. Where the amounts are small, such as for express charges, street car tickets, coal oil, etc., the receipts are all included under one general voucher.

No. 29.—VOUCHER BOOK. We use the voucher system and ordinarily one double page is sufficient for one month, but occasionally it is necessary to use two double pages.

No. 25.

REBATE RECEIPT.
No..............
Date...
M...
No...
From .... 19....
To .... 19....
$....................
Ledger No.................................
SIZE OF ORIGINAL FORM 10″ x 3″.

REBATE RECEIPT.

Terre Haute, Ind..........................19....

No..........

RECEIVED FROM THE TERRE HAUTE WATER WORKS CO. the sum of................................Dollars, being in full for Unearned Water Rent, from..........................19....to..........................19.... at premises No............................street. $................
Ledger No.............. ....

No. 26.

Ledger No.................................

Date........................190..

Mr. ....

Street No...........................

Meter Rebate to December 31, 190..

$......................

METER REBATE.

METER RATE REBATE CHECK.

Ledger No................

Mr............................ Street No................................

The water meter at the above premises for the Twelve months ending December 31st, 190.... shows a consumption of..........................gallons. There has been paid on this account $...................... The minimum rate of $12.00 per year entitles the use of 40,000 gallons. Any excess is 30c. per thousand gallons.

Received of THE TERRE HAUTE WATER WORKS COMPANY, the sum of $...................... ..... rebate as shown above.

....

SIZE OF ORIGINAL FORM 11″ x 2½″.

At the end of each month the columns are footed and the totals posted into the main cash book and then into the ledger. The headings are so arranged that the accounts which are posted into the Ledger are on the first page and on one side of the half leaf. The details of Operating Expenses are entered on the opposite side of the half leaf and on the second page. This form has proven to be a very good one and is entirely satisfactory in every way. We take a page in the back part of the book to keep the footings for each year—one line being used for each month. By entering the totals at the end of each month and making lead pencil footings, we can readily determine the amount expended for any purpose from the beginning of the current year up to the end of the previous month.

No. 30.—Pipe Laying Record. This is a form which I adopted from one used by the Denver Union Water Co. When a block of pipe is to be laid, the form is filled in at the office, as far as possible, so that the street foreman will know exactly what he is to do, where each valve, hydrant and specials are to be located, and also have the minimum amount of writing to do. One form is used for each block of pipe laid. There is space for location of the main at four points on the block.

A sketch is made on the form before it is given to the foreman with the existing main, valves, etc., in red ink and the proposed extension shown in black ink. As each block of work is finished the foreman returns his report so that there is not so much danger of records being lost as if the records of a big job were kept in a memorandum book which the foreman would carry for an indefinite period. If it is desired, the cost can be figured on each block. There is space on the back of the sheet for keeping pay roll. The form is printed on heavy cover paper, and when folded can easily be carried in a coat pocket.

No. 31—Street Record. We use this in book form with

No. 30.

Order No. *Terre Haute, Ind.,* 1

TERRE HAUTE WATER WORKS CO.

Street, from Street, to Street.

Size of Main. Weight per foot. Made by Cost, per ton, Pipe / Specials Bells Look,

Work Began, Work Finished, Water Turned,

Location of Main	ft. in of line of street. Depth from surface of street to top of pipe ft. in. ft. in of " " " " " " " " " " " " ft. in ft. in of " " " " " " " " " " " " ft. in. ft. in. of " " " " " " " " " " " " ft. in

	LOCATION	SIZE	MEASUREMENTS
Specials.			ft. in. of line of street, and ft. in. of line of street.
			ft. in. of " " " " ft. in. of " " "
			ft. in. of " " " " ft. in. of " " "
			ft. in of " " " " ft. in. of " " "

	LOCATION	NAME	OPENINGS	SIZE	YEAR MADE	WATER TURNED ON	ORDERED BY CITY COUNCIL
Hydrants.							

	LOCATION	NAME	Size.	Looks.	Opens to R. or L.	Turns to Open.	Open or Shut.	Well or Box.	MEASUREMENTS
Valves.									ft. in. of line of st. ft. in. of line of st.
									ft. in. of line of st. ft. in. of line of st.

	MAINS		HYDRANT CON		INTERSECTION BRANCHES		TOTAL NO. FEET.	SERVICE PIPE LAID								
Length of Pipe.	SIZE.	NO FEET	SIZE	NO. FEET.	SIZE.	NO. FEET		House No.								
								Long or Short								

Summary.

Approximate weight of Pipe Laid, tons, $

" " " Specials used, lbs.,

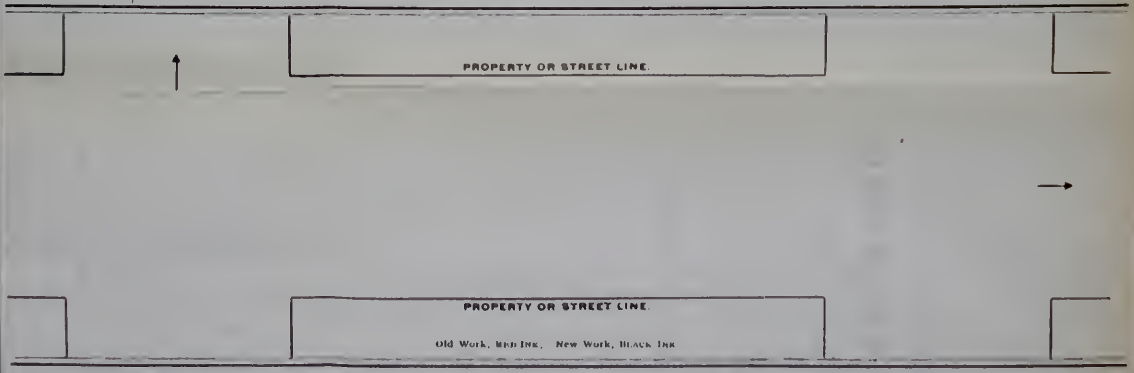
" " " Lead used, lbs.,

Labor,

Hydrants, Valves, Drayage,

Hemp, Valve Boxes, Sundries,

Cost of Labor, per foot Total Cost, per foot Total, $



Superintendent. *Foreman.*

Proceedings American Water Works Association, 1904.

No. 30

No ....

THE

Terre Haute Water Works Co

TERRE HAUTE, IND.

RECORD

OF

PIPE LAYING.

On .... St.

From .... St.

To .... St

WATER TURNED ON

....

....

....

....

....

Entered in Street Record Page ....

By ....

TIME ROLL. TIME ROLL.

No.	NAMES.	S	M	T	W	T	F	S	Total Time	Rate Per Day	AMOUNT		No.	NAMES.	S	M	T	W	T	F	S	Total Time	Rate Per Day	AMOUNT	
											$	Cts.												$	Cts.

Pigs lead used .... lbs.

No. 4-inch joints ....

No. 6 " " ....

No. 8 " " ....

No. 10 " " ....

No. " " ....

Total hours, Foreman .... $ ....

" " Caulkers ....

" " Laborers ....

Total, ...

DRAYAGE.

....

....

....

....

ICE

....

....

....

SUNDRIES.

....

....

....

....

....

....

....

....

two records to a page, each record or account being used for one block of pipe. When the foreman has returned his record of pipe laying, it can be entered into the Street Record and when indexed the information is available on a minute's notice. I have an index bound in the book. In opening our Street Record we arranged it according to the streets, following the plan given in connection with our Consumers' Ledger. Where there were blocks that were not provided with mains and there were prospects of extensions being made in the future, I would leave blank accounts.

There is a big advantage in this system, viz.: information can be added at any time and by keeping a record in the proper account, all the information is available. Our street men have orders to take location of every main they uncover and leave the measurements in the office, and in this connection will say that we have a place on the Service Order for such information, so that every time the main is tapped, the location and depth of the main is recorded.

Where it is necessary to economize, a lot of extra sheets of this form (printed on one side) can be run off when printing is being done for the book, and use them for the street foreman instead of Form No. 30.

No. 32.—ENGINEER'S REPORT. This is a form for a weekly report. and when brought to the office is copied into a book of the same style, except that it is on the monthly plan.

No. 33.—METER STATEMENT BOOK. This book is 5⅝"x 7¾", and contains 20 full sheets and the same number of half sheets. By using the half sheet the book will last for one year. It is a suitable size for carrying in outside coat pocket.

We find it an advantage to divide the city into small districts, with one book for each district.

No. 34.—WASHER ORDER. We put washers in faucets, basin cocks and bath cocks, free of charge, and use this form in giving orders to the men to do the work.

No. 34½.—Requisition.

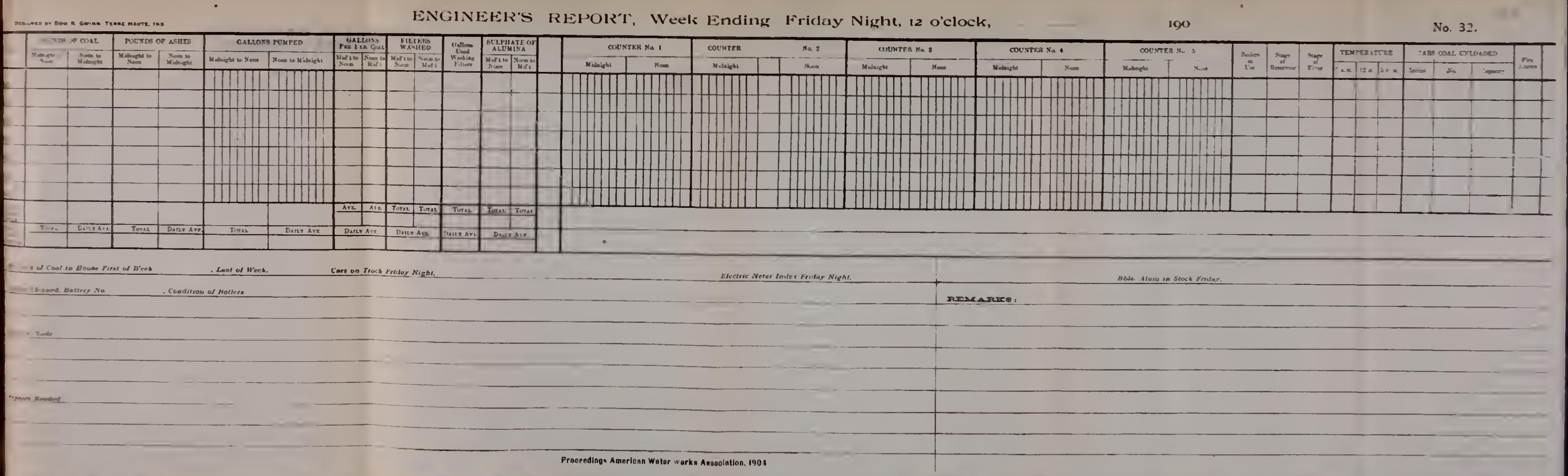
No. 35.—Monthly Report. With our method of entering payments for water under different heads in the Daily Cash Receipts, and with the voucher system of distributing expenses and other disbursements, we can always show the receipts and disbursements in detail. At the end of each month a report is made on this form which gives an immense amount of information. One of the principal advantages of this form is the plan of comparing the receipts and expenses of the month with the same month of the preceding year and also for the period since January 1st with the same period of the preceding year.

The details of operation, number of unpaid bills and amounts of the same, can also be compared for the same month in the previous year. I spent many an hour on this report before it was finally arranged in its present form.

No. 36.—Delinquent Book. At the end of each month a list of delinquents are entered in this book and payments are posted from day to day so that it is not necessary to examine every account in the Consumers' Ledger more than once each month in order to determine who are delinquent.

No. 37.—Meter Book. This book is used for recording setting, removing and repairing of meters. The information is copied from the tags referred to as No. 21, also the inspector's orders.

In conclusion, I will add that most of the forms herein presented are the result of considerable thought and over 22 years experience in every department of the water works business. I was aided very materially in designing these forms by Mr. Charles R. Henderson, Superintendent of the Quincy (Ill.) Water Works, and Mr. M. A. Caldwell, Secretary of the Terre Haute Water Works Co.



DESIGNED BY GEO. R. GWINN, TERRE HAUTE, IND.

ENGINEER'S REPORT, Week Ending Friday Night, 12 o'clock, 190

No. 32.

	POUNDS OF COAL		POUNDS OF ASHES		GALLONS PUMPED		GALLONS PER 1 LB. COAL		FILTERS WASHED		Gallons Used Washing Filters	SULPHATE OF ALUMINA			COUNTER No. 1		COUNTER No. 2			COUNTER No. 3		COUNTER No. 4		COUNTER No. 5		Boilers in Use	Stage of Reservoir	Stage of River	TEMPERATURE			CARS COAL UNLOADED			Fire Alarms	
	Midnight to Noon	Noon to Midnight	Midnight to Noon	Noon to Midnight	Midnight to Noon	Noon to Midnight	Mid't to Noon	Noon to Mid't	Mid't to Noon	Noon to Mid't		Mid't to Noon	Noon to Mid't		Midnight	Noon	Midnight		Noon	Midnight	Noon	Midnight	Noon	Midnight	Noon				7 A.M.	12 M.	5 P.M.	Initial	No.	Capacity		
							AVE.	AVE.	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL																							
	TOTAL	DAILY AVE.	TOTAL	DAILY AVE.	TOTAL	DAILY AVE.	DAILY AVE.		DAILY AVE.		DAILY AVE.	DAILY AVE.																								

s of Coal in House First of Week *. Last of Week.* *Cars on Track Friday Night.* *Electric Meter Index Friday Night.* *Bbls. Alum in Stock Friday.*

leaned, Battery No. *. Condition of Boilers*

REMARKS:

Tools

Repairs Needed

Proceedings American Water Works Association, 1904

GINEER'S REPORT.

Week Ending
Friday Night, 12 o'clock,

.... 19 ....

works business. I was aided very materially in designing these forms by Mr. Charles R. Henderson, Superintendent of the Quincy (Ill.) Water Works, and Mr. M. A. Caldwell, Secretary of the Terre Haute Water Works Co.

PRESIDENT SHERRERD: We would now like to hear from another member of the committee who is here, Mr. Rowe.

MR. ROWE: I mailed about eighty-five letters to as many cities, asking that they give me the system that they have in use for all accounts pertaining to water works department. In reply to those eighty-five letters I received nineteen replies, and I think that you will find that each one of the nineteen is radically different from the others, and with those submitted by Mr. Gwinn. It looks to me very much as if we would never get the different cities to adopt like forms. I do not believe that this committee can ever formulate a uniform system of accounts that would be equally acceptable, say, to the cities of New York and Terre Haute, for instance; and therefore it seems to me the proper thing will be to abandon this committee. The committee, however, does not want to shirk any work. I have gone over these various sets that I have and am certain that continuing the committee would be simply postponing what must result in the end, an abandonment of this idea. Our thanks are due to the cities who responded to the request of this committee and who went to a good deal of work in preparing and furnishing samples of their forms, etc., for our information. I would like to thank them through this channel for their kindness and courtesy in thus assisting us. Outside of that I have nothing further to report in addition to what our chairman has reported.

If in order, I would move that this committee be abandoned.

PRESIDENT SHERRERD: I would like to make a suggestion, if I may in this connection, that it would be well, perhaps, to modify the work of the committee slightly by having them work out a uniform blank for annual reports, and the Chair will entertain a motion that the work of the committee will be continued to include that feature, so that a uniform style of annual report might be considered and reported for the use of the Association.

Mr. Bemis: That is the very motion I would like to make, and do now make. I would like to say a word in regard to it while on my feet. I think it is probably true, as the committee states, that the method of keeping records will not be uniform in all our water works. Probably it is not desirable that we make them so, although we may derive very valuable information from such sample forms as have been presented this morning. But I think there are some things that we could establish on a uniform basis. We could particularly have filled out such a report as is called for every year in the New England Water Works Association, comprising some three or four pages of statistical information. I think that might be extended. We might have some information, for example, somewhat further classifying expenses. The collection expenses might be separated from the pumping expenses. Then, again, we might have such information called for as suggested in the report that Mr. Benzenberg read, so that we might have the estimated present structural value of the plant, present bonded indebtedness, interest on bonded indebtedness, etc. We would then be able to answer the questions that were suggested this morning about Milwaukee and other such cities. Taxes paid might be a separate item, as to private plants, of course. Some of these items private companies might not desire to answer, and might have good reason for not answering. On the other hand, many of the items I think they would be glad to fill out, and the public plants ought in all cases to desire to do so. They would have nothing that they would desire to conceal, I should think, and it would be extremely useful to us. There are only four cities west of the Atlantic seaboard—Cleveland, Oberlin, Madison and Minneapolis—that filled out the blanks of the New England Water Works Association for 1902. We need not necessarily follow their blanks, but we can modify them, it might be, and call for certain additional information.

I would move in accordance with the recommendation of the President that the committee attempt to do that work rather than try to secure uniformity in all the records of the various plants.

RESISTANCE DUE TO BENDS IN PIPES.

APPLICATION OF EXISTING FORMULAS TO A GIVEN CASE.

By John C. Trautwine, Jr.

In a recent case, where a pair of waterworks pumps were installed under the writer's auspices, the contractor for the pumps, upon his first visit to the station after their installation, expressed great surprise at finding that connections like Fig. 1 had been used, both on the pumping mains and on the suction mains, and claimed that the use of such connections was not sanctioned by good engineering practice, and that they offered a much greater resistance than would connections of the form shown in Fig. 2, which were used where admissible.

As the writer would have been sorry to have sanctioned a construction which greatly increased the burden upon the pumps, he has taken some pains to ascertain to what extent the contractor's criticism is borne out in fact, investigating not only the additional resistance probably due to the form of connection used, but also the usage in such matters.

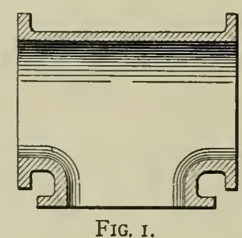


Fig. 1.

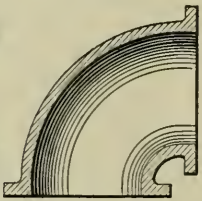


Fig. 2.

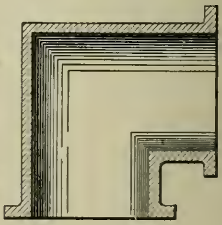


Fig. 3.

The shapes of the connections, as shown in Figs. 1 and 2, were obtained from the founder who furnished the castings. They are well-known, standard types.

As to the additional resistance, due to the use of form 1, instead of form 2, the writer knows of no experimental data and of no formulas applying to this exact case, where form 1 has the same rounding, on the inner side of the bend, as form 2 has. The nearest are the formulas of Weisbach for the resistance in form 2, and for that in a sharp bend, form 3, *without any rounding off of the corners.*

These formulas are as follows:

For right-angle bends, Fig. 3:

$$h = 0.98 \frac{v^2}{2g};$$

For right-angle curves, Fig. 2:

$$h = \left[0.131 + 1.847 \left(\frac{r}{R}\right)^{\frac{7}{2}}\right] \frac{1}{2} \cdot \frac{v^2}{2g};$$

where

h = head in feet required to overcome the resistance due to the bend or curve:

r = inside radius of pipe, R = radius of axis of curve — both in the same unit;

v = mean velocity of flow in pipe, in feet per second;

g = acceleration of gravity = 32.2 feet per second per second.

According to these formulas, for a discharge of 3,000,000 gallons per day (the maximum delivery of each of the two pumps in question), the resistances are as follows:

		Resistance, lbs. per square inch.	Additional resistance of Fig. 3 over Fig 2, lbs per square inch.
14-inch Suction Main	Fig. 3..	0.125	
	Fig. 2..	0.042	0.083
10-inch Force Main	Fig. 3..	0.477	
	Fig. 2..	0.150	0.327

In other words, *if the connections had been of the sharp-cornered form,* Fig. 3, the resistance to flow, through one of these sharp-cornered bends, Fig. 3, would have been greater than that through an elbow like Fig. 2, by less than $\frac{1}{10}$ of a pound per square inch in the 14-inch suction main and by less than $\frac{1}{3}$ of a pound per square inch in the 10-inch force main.

As the average suction lift is about 16 feet (= 6.9 pounds per square inch) and the average force-main pressure say 100 pounds per square inch, a sharp-cornered bend, like Fig. 3, *if it had been used,* might have added nearly $1\frac{1}{4}$ per cent. to the resistance in the suction main, and nearly $\frac{1}{3}$ of 1 per cent. to the resistance in the force main.

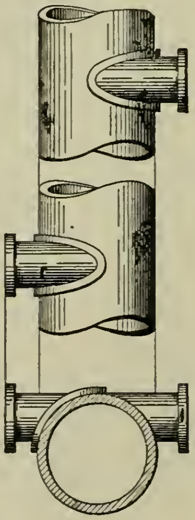


FIG. 4.

How much less the difference is, with the rounded bends, Fig. 1, actually used, the writer has no means of knowing; but it would certainly be much less than the very small figures above calculated. Indeed, it is very questionable whether the additional resistance could be detected.

As to usage, the writer found that the suction connections to the existing pump, installed some years before by the Holly Company, are of form 1, as are those proposed by the same company in bidding on the new installation.

Another well-known bidder on the new installation submitted a design involving similar connections on the suction mains.

Fig. 4 shows the arrangement of suction mains for the new high-pressure fire-service pumping station in Philadelphia, in which the branches, to the several pumps, are led off at right angles from the suction main, without any rounding off such as is shown in Fig. 1.

It appears, therefore, that the arrangement installed has the sanction of usage, and that the additional resistance, due to its use, is, at the worst, quite insignificant.

PROF. GARDNER S. WILLIAMS, Hydraulic Laboratory of Cornell University (by letter):

Regarding the question of resistance due to rectangular and rounded bends in pipe, and the application thereto of the formula usually presented in the text books on Hydraulics, it is to be remembered that those formula are based almost entirely upon the experiments of Weisbach as interpreted by himself some sixty years ago, and although the formulæ, by universal quotation by writers upon the flow of water, have come to be regarded as almost indisputable, the fact remains that the conditions under which the experiments were made were such as later investigation has proven to be insufficient to afford accurate determinations of the quantities sought. Weisbach's experiments upon the resistance of curves and bends*, as well as on most of the obstructions to flow investigated by him, were inaccurate as to quantitative results, because there was not a sufficient length of pipe between the obstruction and the outlet to enable the true resistance to be developed.

It has been found experimentally† that when water flows around a curve or through a contraction the flow is distorted and losses of head occur due to the distortion until the water has readjusted its flow to normal conditions, which in the case of curves requires a length of about 200 diameters of the pipe beyond the curve, and in the case of contraction about 35 diameters. As Weisbach apparently never had, with a single exception, a length of more than 10 diameters beyond the curves, the application of the data of his experiments is likely to be accompanied by considerable error.

Whatever practice may be in regard to the form of branches on water pipe, the fact that the discharge over a dam with a flat crest 6.5 feet wide and 4.5 feet high may be increased over 10 per cent. by rounding the upstream corner to a four inch radius* proves pretty conclusively that a rounded entry is decidedly preferable to a square edged one, and that specials of the form of Figures 3 and 4 are not to be recommended, however eminent an authority may be using them. In the case of Figure 1, assuming the water to feed the branch from both sides, the ideal form for the surface at the junction would be the *vena contracta,* which involves a small radius at its inlet, probably not very different from the ones shown. In cases of this kind a rounding of the corners is certainly desirable, but it is probable that a radius equal to not more than one-fourth of the diameter of the pipe is all that is necessary.

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*See "Technic" University of Michigan, Ann Arbor. 1899.

†See Transactions Am. Soc. Civil Engrs. Vol. XLVII, pp. 317-320 and 328.

For the case of a 90 degree change of direction in a pipe, the curve of least resistance has been found experimentally† to be one of about two and one-half diameters radius on the center line, the loss of head involved between two points equidistant from the intersection of the two tangents increasing as the curve increases or decreases its radius from this. At best a right angled bend may be expected to increase the loss of head in the section of pipe affected by it some 7 per cent., and the length so affected will be about 200 diameters of pipe plus the length of the curve. It therefore appears that such a bend in a twelve inch pipe would introduce a loss of head equal to about fourteen feet of straight pipe. This excess loss of head may be easily increased to three or four times this amount by using a longer radius curve.

In a series of experiments made upon the water mains of Detroit† it was found that in a 30 inch pipe various specials and curves introduced losses of head equivalent to those in the following lengths of straight pipe:

---

*See Transactions A. M. Soc. C. E. Vol. XLIV, p. 330, plate XV.

‡See Transactions Am. Soc. C. E. Vol. XLVII, p. 360.

30 in. x 10 in. Y. or 30 in. x 6 in. Cross, or two 30 in. x 6 in. Tees		3.12 ft.
30 in. Double Disc Gate Valve		15.62 ft.
6 ft. Radius 90 deg. curve	2.4 diam. Radius	36.06 ft.
10 ft. Radius, 90 deg. curve	4. diam. Radius	52.16 ft.
15 ft. Radius. 90 deg. curve	6. diam. Radius	74.99 ft.
60 ft. Radius. 90 deg. curve	24 diam. Radius.	And reversing and joined by 73.58 ft of tangent. 188.43 ft.
40 ft. Radius. 90 deg. curve	16 diam. Radius.	

A comparison recently made, under the writer's direction, of the losses introduced by passing water from a 5 inch to a 2 inch pipe through a square edged contraction, and through one with rounded edges, the radius of curve of the rounding being one-fourth of the diameter of the smaller pipe, showed that the former caused a loss of head greater than the latter by an amount equal to the loss in from three to four feet of the smaller pipe. Whether this quantity is to be considered important, depends entirely upon the total losses of head involved and the means of overcoming them.

Mr. Hering (by letter): The resistance due to bends in large pipes has not as yet received the attention which it merits, and a systematic series of experiments, if it were made, would contribute very useful knowledge on this subject.

Mr. Trautwine has applied Weisbach's formula to the pipes of 10-inch and 14-inch diameter. If I remember rightly, this formula was deduced in Freiburg from laboratory experiments in pipes of much smaller diameters, and may not apply within reasonable degrees of accuracy. I do remember a case in a Western city, where by pressure gauges on what I think was a 48-inch force main, the loss of pressure due to two or three rectangular bends was something like 10 feet.

It also makes a difference whether in Figure 1 the water flows away in both or only in one direction. Friction of water against an iron surface is less than friction of water against water.

Experiments on the flow of water through bends and other obstructions in large pipes would settle this and other important questions.

534a

WATER HAMMER.

By O. SIMIN.

ERRATA AND REMARKS.

PAPER ON WATER HAMMER.

By O. Simin.

Pages 356 and 365. Figs. 6 and 8. The letter A should be near the "origin," or point where the small pipe leaves the large main.

Page 360. Fig. 7. The selection of a pipe of such length that the pressure wave occupies just four seconds in traversing it, and the selection of points 0, 1, 2, 3 and 4 for illustration, were matters of mere convenience.

Page 362. For $=$ the weight of a unit of volume of water, read $\gamma =$ the weight of a unit of volume of water.

Page 368. Fig. 9. The letters M and N should appear at the ends of the dotted line pertaining to the inner semicylinder.

Page 368. Fourth equation from foot, for R read R_o.

Page 369. Lines 8 and 9. For increase, P, of pressure, read increase, P, of unit pressure.

Page 369. Table II. Title. For Theoretical read Calculated.

Pages 375 and 376. Tables V. and VI. For Velocity, in Feet per Second, read Velocity, v, of water, in Feet per Second.

Page 391. Lines 10 and 11. For dead end of the small pipe, read dead end formed by the small pipe.

Page 393. At end of foot note, add, as in Figs. 20.

Page 374. Line 4 from foot. For the nearest to the beginning of the pipe, read the nearest to the gate.

Page 417. Fourth paragraph from foot. Read The distance on the diagram from the first increase of pressure to each of the three depressions, a, b and c, Fig. 26, expressed in time units, was found to be in all cases equal to the time required for a round trip of the pressure wave from the point where the diagram was taken to the air pocket and back. This enables us readily to locate an air pocket by means of the diagram.

Insert between pages 336 and 337.

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WATER HAMMER.

BY O. SIMIN.*

INTRODUCTION.

THE question of the so-called "water hammer" or "hydraulic shock," caused by stopping the flow in a water pipe, is of great practical importance, as the shock frequently bursts the pipe.†

Although the phenomenon has been long known, yet its nature has not been studied and explained until lately. Previous explanations were little better than guesses, and the effects upon the pipe could be neither foreseen nor avoided.

Efforts to understand the phenomenon were indeed made, but experiments upon a sufficient scale were lacking, and even as late as in 1897 and 1898, when the subject had been taken up by the American Society of Civil Engineers,* the result of the discussions was that the existing data were insufficient and that more experiments were needed.†

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* The writer here undertakes merely a compilation of existing information respecting this subject, including especially a digest of the notable work of Prof. N. Joukovsky, at Moscow, in 1897, which, in fact, embodies what is now known of the subject.

The present paper involves no original research. It was written at the suggestion of Mr. John C. Trautwine, Jr., while the writer was engaged in his office. The writer is indebted to Mr. Trautwine and to Mr. Boris Simin for suggestions and for corrections of proofs.

The writer has frequently quoted (in translation) the language used by Professor Joukovsky.

† Geo. M. Peck describes water hammer as follows:

"When a liquid is flowing through a pipe there is a certain amount of energy in the liquid, and if we stop the flow this energy must be used up in some way.

"If the liquid is incompressible, and we stop the flow suddenly, the energy of the liquid is used up in doing work on the pipe by stretching it or increasing its diameter.

"If the liquid is compressible, the energy of the liquid is used up in compressing the liquid and stretching the pipe. Nearly all bursting of pipes is due to a sudden checking of the velocity of the liquid or to the freezing of the liquid." (See *Trans. Am. Soc. of M. E.*, Vol. XXI, December, 1899.)

Since then more satisfactory experiments have been made in connection with a general mathematical study of the problem, and formulæ governing the phenomenon have been established and experimentally proved to be correct.

Before describing these experiments and their results, let us glance at the history of the subject from the beginning. We shall thus see how the study gradually developed, the work of one investigator starting from that of another, the study thus gradually growing, from small beginnings, into a broad general mathematical theory, giving the phenomenon its proper place in the science of hydraulics, and furnishing a solid footing for practical men in their engineering work.

A. EARLIEST THEORETICAL STUDIES.

The earliest studies of the propagation of hydrodynamic pressure in pipes with elastic walls were purely scientific, and did not refer to water pipes. They related chiefly to acoustic and physiological phenomena (such as the pulse in animals), which, as we know now, are governed by the same laws as are hydraulic pressure waves‡ in water pipes. Such were the studies of Marey, of Resal (1876), of Gromeka (1883), of Korteveg (1878), and lately of Lamb (1898), who established formulæ for the pressure waves; but these formulæ were hardly thought of in connection with the engineering question of water hammer.

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* See *Trans. Am. Soc. of C. E.,* Vol. XXXIX, June, 1898.

† See quotations on page 346.

‡ German, "Stosswellen."

It will perhaps be surprising to many to learn that water hammer is merely a special case of the phenomena of wave action covered by these formulæ.

While the wave-like transmission of water hammer has indeed been recognized, notably by Frizell, the true nature of its relation to the subject has not hitherto been realized. This may be due in part to the fact that most of the earlier experiments were made with relatively short pipes, in which (the wave traveling with from 3 to 4 times the velocity of sound in air) its transmission could not well be observed and studied in detail, as it was in the experiments of Joukovsky.

B. AMERICAN STUDIES OF THE HYDRAULIC SHOCK IN ITS APPLICATION TO WATER PIPES.

A practical study of water hammer in pipes began in America in 1884. At that time appeared an article, by the late John W. Nystrom, in *Mechanics* (August, 1884),* and the experiments of Ed. B. Weston in Providence, R. I., were described by him in a paper presented to the American Society of Civil Engineers in 1885.†

Mr. Weston's experiments were made upon a rather small scale: the first series with about 111 feet of 6-inch pipe, 58 feet of 2-inch pipe, 99 feet of 1½-inch pipe and 4 feet of 1-inch pipe; the second series with 111 feet of 6-inch pipe, 3 feet of 3-inch pipe, 58 feet of 2-inch pipe,

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* See notice in the *Journal of the Franklin Institute,* April, 1890, page 328, and in *Engineering Record,* August 11, 1894, page 173.

† See *Trans. Am. Soc. of C. E.,* June, 1885, pages 238 and 246½ *Engineering Record,* August 11, 1894, page 173; *Trans. Am. Soc. of C. E.,* June, 1898, pages 1 and 5; *Journal of the Association of Engineering Societies,* February, 1889. page 103.

96 feet of 1½-inch pipe and 4 feet of 1-inch pipe; and the third series with 181 feet of 6-inch pipe, 65 feet of 4-inch pipe, 3 feet of 2½-inch pipe, 1 foot of 2-inch pipe, 6 feet of 1½-inch pipe and 6 feet of 1-inch pipe.

The aim of these experiments was to ascertain the maximum pressure caused by a sudden stoppage of flow. A rapidly closing gate and a steam indicator were used. "The pressures were recorded by a style, which drew a straight mark upon a stationary paper, and the diagram took no account of the oscillations which succeeded the main shock incident to the stoppage of the current."*

The quick-closing gate was thought to occupy 0.15 second in closing, a time which, as we now know, was sufficient for the pressure wave to run to the end of the pipe and to return before the gate was completely closed. This affected the resultant pressure, and the full pressure, due to closure, could never be obtained. Mr. Weston made no attempt to deduce mathematical formulæ from his experiments.

In 1889, Mr. S. Bent Russell, of St. Louis, endeavored, by means of experiments, to frame an empirical formula for the intensity of water hammer.† He correctly established the fact that the intensity of the shock is proportional to the velocity of the arrested flow of water; but he assumed that it depended also upon the mass of the moving water and consequently upon the length of the pipe line. As seen from later studies, this assumption was incorrect, as was also Mr. Russell's empirical formula.

In 1890 Prof. Irving P. Church made a theoretical study of the subject.‡ Professor Church assumed that the maximum increase of pressure depends upon the manner of closing the gate valve, which, as has since been shown, is not the case.*

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* *Trans. Am. Soc. of C. E.,* June, 1898, page 1.

† See *Journal of the Association of Engineering Societies,* February, 1889, page 100.

‡ See *Journal of the Franklin Institute,* April, 1890, page 328, and May, 1890, page 374; *Engineering Record,* August 11, 1894, page 173; *Trans. Am. Soc. of C. E.,* June, 1898, page 2; Joukovsky, page 3.

In 1892-93 the subject was studied by Messrs. S. H. Barraclough, B.E., and A. W. Wigglesworth, M.E., graduates of Sibley College, Cornell University, under the auspices of Prof. R. C. Carpenter.†

In the first series of these experiments there were used 375 feet of 6-inch pipe, 150 feet of 3-inch pipe, 33 feet of $2\frac{1}{2}$-inch pipe and 30 feet of 2-inch pipe; in the second series, 53 feet of $1\frac{1}{2}$-inch pipe.‡ The velocity of flow reached 8.6 feet per second.

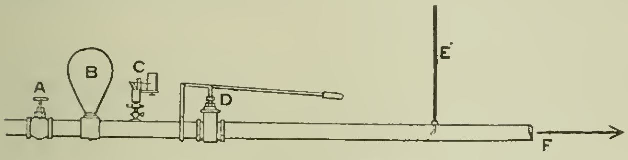

FIG. 1. CARPENTER'S EXPERIMENTAL APPARATUS.

"Water passed through the pipe in the direction from A to F (Fig. 1) under a pressure of 2 atmospheres. The velocity of flow was regulated by gate A and recorded by means of the Pitot tube E. The stoppage of the flow was effected by means of a throttle-gate, D, operated by hand. A pressure indicator, C, showed the variations of pressure, tracing, by means of a pencil, a diagram on a paper placed on a rotating cylinder. Between the gates A and D was placed an air chamber, B, which could also be used as a water chamber or could be removed altogether. Experiments were performed (a) with air chamber, (b) with water chamber and (c) without chamber."§

---

* Joukovsky, page 3.

† See *Transactions* of the New York meeting of the Am. Soc. of M. E.; *Engineering Record,* August 11, 1894, page 173.

‡ See *Trans. Am. Soc. of C. E.,* June, 1898, page 5.

§ Joukovsky, German edition, page 4.

These experiments were scientifically performed, and Professor Carpenter discusses the subject theoretically, confining himself, however, to the determination of the maximum increase of pressure.

On October 6, 1897, Mr. J. P. Frizell presented to the American Society of Civil Engineers a paper on water hammer, under the title, "Pressures Resulting from Changes of Velocity of Water in Pipes."*

"He was led to the study of this subject from its connection with the regulation of water wheels, drawing through long penstocks, and from the fact that requirements of electric transmission call for greatly increased exactness in the regulation of wheels."

Mr. Frizell made no experiments himself, but he studied the subject as it appeared from the experiments of Messrs. Weston, Carpenter and Church, and the aim of his paper was to give a general explanation of the phenomenon and mathematical formulæ respecting it. Professor Joukovsky's results, which satisfy the requirements of theory, have shown the formulæ derived by Mr. Frizell to be incorrect, but he gives a clear and correct view of the subject in general.

The paper of Mr. Frizell was followed by a discussion, in which many prominent engineers took part. Almost all who discussed the paper expressed the opinion that the subject is an important one, but that data in regard to it are scarce and that more experiments are wanted. Following are quotations from the discussion:

MR. RUDOLPH HERING.—"In view of the fact that opportunities for properly conducting such experiments are rare, the making of even imperfect sets of experiments should rather be encouraged."

MR. GARDNER S. WILLIAMS.—"The literature on the subject is extremely limited, and anything which may throw ever so little light upon it seems worthy of consideration."

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* See *Trans. Am. Soc. of C. E.*, June, 1898, page 1; see also short remark in the *Minutes of Proceedings of the Institution of Civil Engineers*, Vol. CXXX, 1897, page 351.

MR. HENRY GOLDMARK.—"The theoretical values obtained by the author's formulæ are higher* than those which have generally been used in designing. For this reason it is all the more desirable that their correctness should be practically tested by an extended series of experiments on hydraulic plants in actual operation."

MR. THERON A. NOBLE.—"It is to be regretted that the author could not have supplemented his analysis with an account of some tests to show that the formulæ could be used with safety. Such an investigation, following his analysis, would be very valuable, and it is to be hoped that some engineer who has the opportunity will find out what actually occurs in a long pipe line of uniform diameter when the water is suddenly shut off."

MR. J. P. FRIZELL.—"The paper attempts to deal with an important engineering problem from a mathematical point of view, and therein differs from the general character of the papers presented to the Society, which more commonly deal with experimental and practical results. By way of excuse for this departure, the author would observe that, while no formula which rests wholly upon theoretical considerations can be used with confidence, it is nevertheless true that a clear comprehension of the theory of a subject is a necessary and indispensable preliminary to any intelligent experiment."

---

* They were much higher also than the actual values obtained in Joukovsky's experiments.

Example given by Frizell: A velocity, $v = 4$ feet per second, is checked in a steel pipe of 60 inches diameter and with wall ¼ inch thick. Modulus of elasticity of steel, $E = 30{,}000{,}000$ pounds per square inch.

The speed of pressure wave λ and the additional shock pressure P, as derived from Frizell's and Joukovsky's formulæ, are as follows:

(1) Frizell:

$\lambda = 4272$ feet per second. $P = 230$ pounds per square inch $= 15.65$ atmospheres.

$h = \frac{P}{v} = 3.9$ atmospheres per foot of extinguished velocity.

(2) Joukovsky:

$\lambda = 2556$ feet per second. $P = 138$ pounds per square inch $= 9.4$ atmospheres.

$h = \frac{P}{v} = 2.35$ atmospheres per foot of extinguished velocity.

While this discussion was in progress, important experiments upon an unprecedentedly large scale were being conducted in Moscow, Russia.

C. STUDY AND EXPERIMENTS OF N. JOUKOVSKY.*

I. *Organization and Character of the Experiments.*

When the new Moscow waterworks (now in use) were projected, the question came up as to the velocities which could be safely allowed in water pipes of small diameters.

Mr. Nicholas P. Simin, then chief engineer of the Moscow waterworks, advised following the recommendations of Mr. J. T. Fanning and other prominent engineers,† to allow, in small pipes, velocities not exceeding 1 meter per second, in order not to subject the water pipes to danger of water hammer. This recommendation was not adopted, the Imperial Supervising Commission of the Moscow Waterworks being in favor of higher velocities. Mr. Simin then proposed to organize a series of large-scale experiments upon water hammer in pipes.

---

* See "Ueber den Hydraulischen Stoss in Wasserleitungröhren," von N. Joukovsky. 1898. *Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg,* Classe physico-mathématique, Vol. IX, No. 5. (Edited in Russian and in German.)

† See, for instance, "A Practical Treatise on Hydraulic and Water-Supply Engineering," by J. T. Fanning," 1884, page 508, paragraph 495, table 105.

This proposition was adopted, and in the summer of 1897 experiments were started under the charge of N. Joukovsky, professor of the University of Moscow and of the Moscow Imperial Technical Institute.

These experiments were finished in the winter 1897-98, and resulted in the paper of Professor Joukovsky, which contains a thorough discussion of the subject.

Professor Joukovsky's report commences with a mathematical analysis of the phenomenon leading up to the derivation of a formula. He then gives a detailed description of the experiments by which the correctness of the formula was demonstrated, and sums up, in a number of conclusions, the principles of the phenomenon. In the spring of 1898 this paper was presented to the Polytechnic Society in Moscow and to the Imperial Academy of Science in St. Petersburg, and later to the fourth Russian Waterworks Convention, held in Odessa.

Professor Joukovsky gives a complete analytical explanation of the phenomenon in all its phases. His method of reasoning is purely mathematical and deductive. Starting from a general differential equation and using a mathematical method given by Riemann, Joukovsky explained all cases of water hammer by the transmission of a pressure wave in the water pipe and by its reflections from the ends of the pipe.

In the analytical determination of the velocity of transmission of this pressure wave, Joukovsky deduces a formula which fully agrees with the formula given by Korteveg* for the transmission of *sound* in an elastic pipe filled with a compressible liquid. Joukovsky showed by his analysis, and demonstrated by his experiments, that the formula of Korteveg applies not only to acoustic phenomena (for which it was established), but also to water hammer in pipes.

---

* D. Korteweg, "Over Voortplating-snelheid van golven in elastische buizen," Leiden, 1878.

The full analytical solution of the problem by Joukovsky is too complicated for introduction here, but the principles involved and the leading formulæ will be explained.

As special cases of the phenomenon of water hammer, Joukovsky has investigated:

1. The influence of dead ends, which increase the shock.

2. The effect of the rapidity or slowness with which the gate is closed.

3. The effect of air chambers.

4. The effect of safety valves.

5. The influence of air pockets and of leaks from pipes upon the form of the pressure curve, enabling us to locate such difficulties by means of the curve.*

The experiments were made with 6-inch, 4-inch and 2-inch pipes.

The 6-inch line was 1066 feet long.

The 4-inch line was 1050 feet long.

The 2-inch line was 2494 feet long.

All these pipes were laid on the surface of the ground in the yard of the pumping plant (Fig. 2); each of the lines formed a loop, starting from the 24-inch waterworks main (also shown on the sketch) and ending at the well, g, where a quick-closing gate was placed.

The 24-inch main, 7007 feet long, was also subjected to experimental water hammer.

All the pipes, including the 2-inch, were of cast iron.

In all the experiments the closing was effected by means of a quick-closing gate, governed by a weight which hung from a pulley, and which was dropped from a certain constant height when the flow was to be stopped.

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* Professor Joukovsky has also theoretically investigated the case of water hammer in a pipe on which a standpipe is placed; but this subject is not included in his paper, here quoted, or in the present paper.

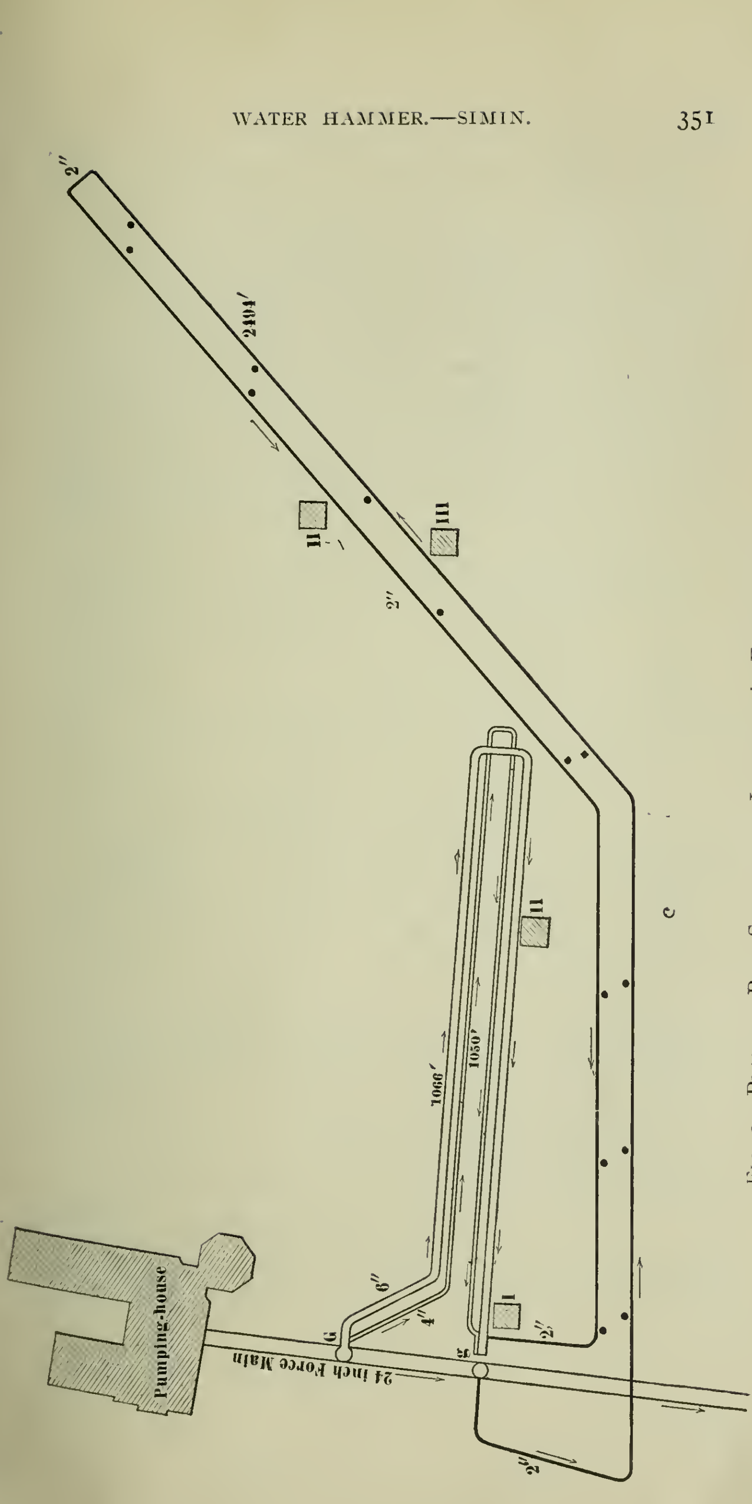

Fig. 2. Plan of Pipe System for Joukovsky's Experiments.

The resulting pressures were recorded by instruments of three kinds, viz: (1) 11 Bourdon manometers, which were placed along the pipe lines at the points shown in Fig. 2; (2) 3 specially constructed Crosby indicators, which were placed in small, portable frame houses, I, II and III, set in different points of the pipe lines; and (3) a Marey chronograph, which stood in the pump house, and which was connected, by means of electric currents, with *2* special manometers, shown by square dots.

All these devices were electrically connected, each half-second being recorded by a special pendulum, which stood in the pump house and which sent electric currents to the Crosby indicators on the pipe lines.

The Marey chronograph marked every 0.01 second by means of a tuning fork, which was connected by electric current with the chronograph.

The Bourdon manometers were used for determining the *intensity* of pressure obtained in water hammer. The Crosby indicators showed the variation of the *intensity* of the pressure and the *speed* of propulsion of the pressure waves. The Marey chronograph served only for the direct determination of the *speed* of the pressure waves.

A great number of pressure diagrams were obtained by means of the indicators and of the chronograph, both kinds of diagrams being drawn on paper placed upon a revolving cylinder.

The indicator curves were especially interesting, as they showed all the oscillations of pressure in different points of the pipe line, records being obtained at the same instant in different points. These curves formed autographic records of the pressure-wave movements.

Many tables were computed from these curves.

II. Explanation of the Phenomenon of Water Hammer.

In cases of water hammer, as already shown by Carpenter, a very rapid oscillation of pressure results, the pressure rising above the normal, then falling below the normal, then again rising, and so on, the amplitude of the vibrations gradually diminishing until the normal pressure is again established. But, owing to the shortness of the pipes used in Professor Carpenter's experiments and to the insufficient exactness of his measuring apparatus, the laws governing this variation of pressure could not then be established.

Joukovsky used Crosby indicators, each with a very rapidly moving ribbon of paper, upon which pressure diagrams on a large scale were traced, giving a detailed record of the oscillations of pressure.

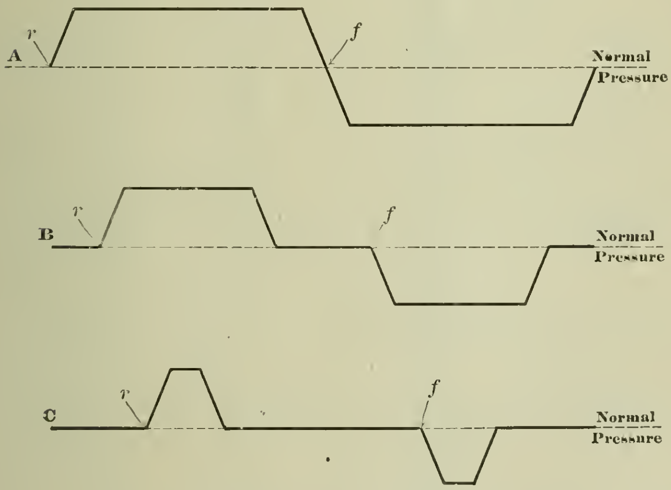

FIG. 3. THREE TYPES OF PRESSURE CURVES.

Curves of three types were obtained, and these types are schematically represented in Fig. 3, in which the horizontal

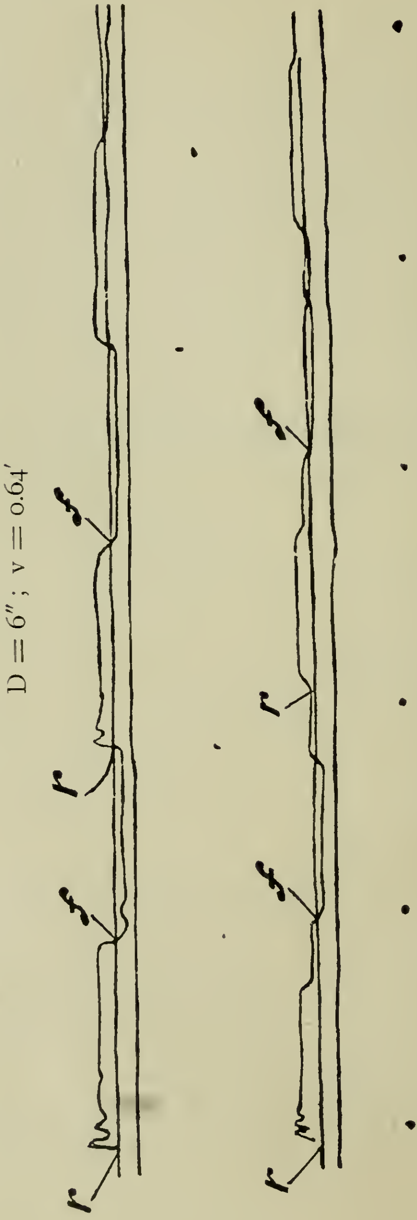

Fig. 4. Indicator Diagrams in Two Points of the 6-inch Pipe.

axes represent time. In Figs. 4 and 5 are reproduced, on a small scale, curves actually obtained by means of the apparatus.

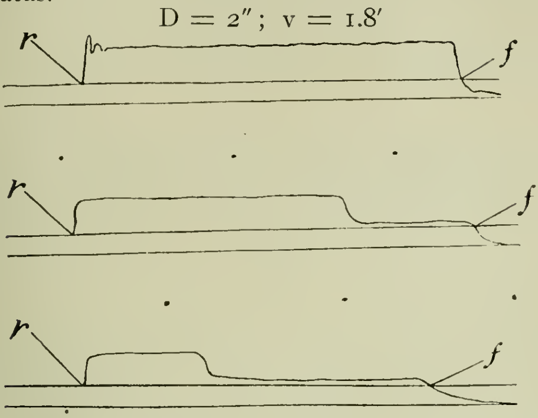

FIG. 5. INDICATOR DIAGRAMS IN THREE POINTS OF THE 2-INCH PIPE.

In each of these diagrams, the time, from the beginning, r, of rise of pressure above the normal, to the beginning, f, of fall below the normal, is the same for all points of the same pipe. Joukovsky found that this time is equal to that required for the wave, with velocity, λ (calculated theoretically and verified experimentally), to travel from the gate to the origin* and back.

At the gate (Fig. 3, A) the transition from supernormal to subnormal pressure, or *vice versa,* is not interrupted by any period of normal pressure; but at all other points in the pipe such periods of normal pressure intervene, giving the "stepped" diagrams of Figs. 3, B and C.

The diagrams obtained have shown also that for any given point the period of supernormal pressure is equal to the period of subnormal pressure, and is proportional to the distance between said point and the origin.

---

* By "origin" is meant the beginning of "the pipe," *i. e.,* of that portion of the system which is notably affected by the closing of the gate. Back of the origin the velocity is negligible and the pressure practically unaffected by the closing of the gate. Thus, the origin may be the point where the pipe under experiment leaves a reservoir or a main of large diameter.

The explanation of these facts follows from the theoretical consideration of the phenomenon.

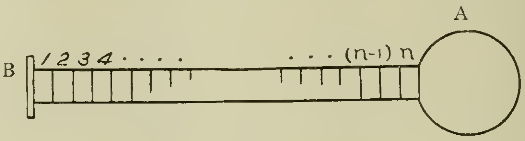

Fig. 6.

In Fig. 6 let A B be a pipe, in which water flows with velocity, v, from the origin, A, past the gate, B. If, now, the flow is suddenly stopped by a rapid shutting of the gate, B, the kinetic energy of the water column, A B, will cause an increase of pressure in the pipe.

Let us consider the column of water, A B, as divided into n very small equal sections, 1, 2, 3, ... (n — 1) and n.

The phenomena of water hammer take place in a series of cycles, each consisting of four processes, as follows:

(1) Section 1, meeting, in the gate, an obstacle to its movement, will be compressed and will stretch the pipe wall surrounding it. All the kinetic energy of this section of water will be used up (a) in its own compression, resulting in the increase of pressure by an increment, P, and (b) in the corresponding stretching of the walls in section 1 of the pipe. As a result of this action, section 1 of the water column has left vacant behind itself a small space, to be occupied by a part of the next arriving section 2. Consequently it is only after section 1 has been stopped and compressed, and after the small space thus left has been filled, that section 2 can be arrested and compressed.

Now the kinetic energy of section 2 must be expended in some way. Will it increase the pressure upon the gate, which has already been caused by the arrest of section 1? No, and for the following reason:

The pressure upon the gate depends entirely upon the pressure, P, sustained by section 1, which is now in static condition.

The pressure upon the gate could therefore be increased only if section 1 could be farther compressed, and this could take place only if the pressure upon the surface between it and section 2 (which we may imagine to be a thin piston) could be greater from the side of section 2 than it is from the side of section 1; and this is impossible, because section 2 has only the same kinetic energy as section 1, and this energy will (as in the case of section 1) be used up entirely in compressing the water of the section (section 2) only to the same additional pressure, P, and in stretching that part of the walls surrounding section 2.

The same is true of each following section, 3, 4, ... (n — 1) and n; each of these sections, as it is arrested, being compressed to the pressure, P.

During process (1) a small quantity of water flows from the reservoir into the pipe, to occupy the space formed by the compression of the water and the extension of the pipe walls.

Finally, when all the sections have been arrested, the entire column will be under the pressure, P. The entire energy of the water column is now stored (as potential energy) in elastic deformation, viz, in the compression of the water column and in the extension of the pipe walls.

But this condition cannot be maintained; for

(2) As soon as the additional pressure, P, has been produced in the last section, n, the water in that section will again expand, and the walls of that section of the pipe will again contract, restoring the original conditions in that section, and pushing the water of that section back into

the reservoir* from which the pipe issues, and restoring the original normal pressure in section n.

This operation will now be repeated by each section (n — 1), ... 4, 3, etc., in turn, until all the potential energy, stored in the water column when it was under the pressure, P (neglecting the portion lost in friction), has been reconverted into kinetic energy.

During process (2) the water which entered the pipe during process (1) is forced back into the reservoir.

The condition of the water column is now what it was just before the gate was closed, except that its velocity, v, has now the opposite direction, *i. e.*, toward the origin.

(3) The kinetic energy of the water column, moving toward the origin or away from the gate, is now reconverted into potential energy, which manifests itself in an extension of volume of the water to a subnormal pressure,† beginning with section 1, and concluding only when the entire water column has been reduced to the subnormal pressure.

During process (3) water continues flowing from the pipe into the reservoir.

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* We here use the word "reservoir" to denote the supply of water, back of the origin, whatever may be its character. See page 355, footnote.*

† As in other cases of vibration, the subnormal pressure, thus produced, should always fall as much below the normal as the supernormal pressure rose above the normal, except that the amplitude of the vibrations should be gradually diminished by friction. But the experiments have shown (see pressure diagrams, Fig. 13) that the fall of the subnormal below the normal pressure is much less than the rise of the preceding and following supernormal pressure above the normal; and this discrepancy is very considerable when the subnormal pressure approaches or even falls below the atmospheric pressure. In such cases water vapor and air are disengaged from the water, and possibly some air is inhaled through the pores in the walls of the pipe. These factors, of course, raise the subnormal pressure above what it should theoretically be.

(4) When the subnormal pressure has been established throughout the length of the pipe, and all the water has come to rest, the water from the reservoir will again direct itself into the pipe, restoring the normal pressure, first in section n, next to the reservoir, and then, in rapid succession, in the other sections (n — 1), . . . 4, 3, etc., until, when the normal pressure reaches the gate, we have once more the conditions which existed just before the gate was closed, viz, the normal pressure is restored and the water is moving toward the gate with the original velocity, v.

We have now followed these pulsations of pressure (with the accompanying transformations of energy and flow of water into and back from the pipe) through a complete cycle of four movements, each extending through the length of the pipe. For convenience, we may consider two successive movements of this kind as a "round trip" through the pipe.

The gate remaining closed, the whole process is now repeated in a second cycle, which, in turn, is followed by a third, and so on, the amplitude of the pressure vibrations gradually diminishing (because of friction) until the pipe and the water come to a state of rest.

But although the *intensity* of the pressure becomes gradually less, the *time* required for each cycle remains constant for all repetitions.

This propagation of pressure, consisting of its transmission through all points of the length of the pipe, each point successively repeating the same periodical movements, is, in its nature, simply a case of wave motion, like that of a sound wave.

The velocity of wave propagation is independent of the intensity of the pressure, and depends only upon the properties of the medium through which the propagation takes place—in the case of water hammer, upon the elasticity of the water and of the pipe.

We now find that the time required for each cycle of pressure transmission (including 2 round trips through the pipe) is equal to $\frac{4l}{\lambda}$, where l is the length of the pipe and λ is the velocity of wave propagation. This is the period of an entire pressure vibration in every point of the pipe.

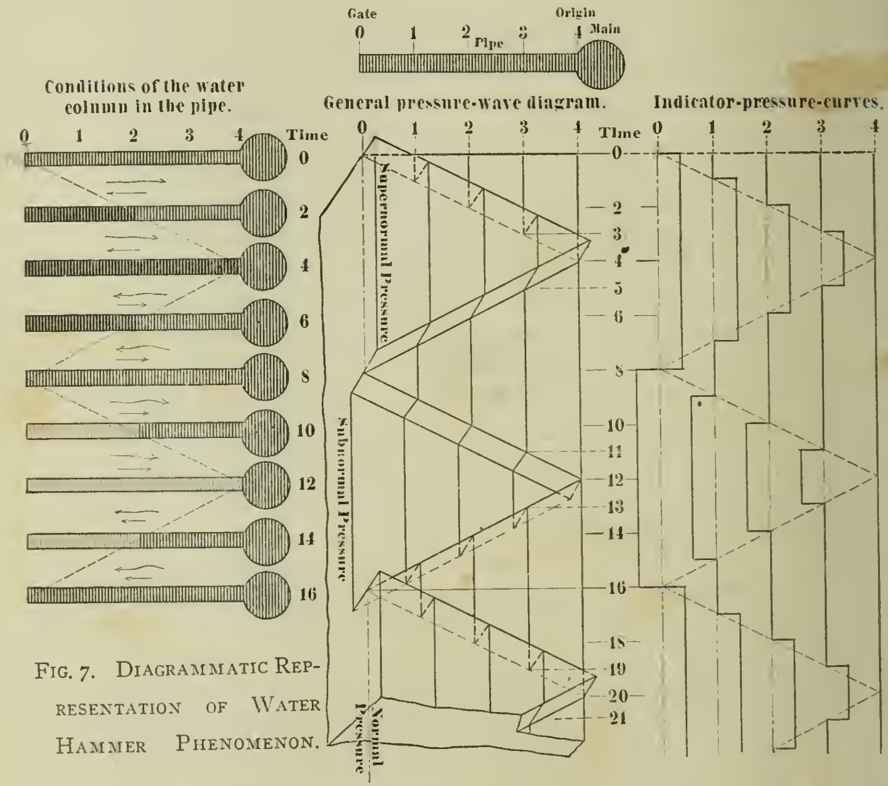

FIG. 7. DIAGRAMMATIC REPRESENTATION OF WATER HAMMER PHENOMENON.

A general diagrammatic representation of the principles of water hammer, as just described, is given in Fig. 7. Here we see, on the right, pressure curves of the same character as those in Fig. 3, corresponding to the different points of the pipe indicated at the top. On the left of

Fig. 7 the conditions of the water column in the pipe are shown at different instants during the propagation of the pressure waves back and forth along the pipe, sections under supernormal, normal and subnormal pressure being indicated by heavy, medium and light shading, respectively. To the right of the diagonal lines, crossing these sections, the pressure is always normal. To the left it is supernormal in the second, third and fourth sections from the top, and subnormal in the sixth, seventh and eighth.

Arrows drawn with straight lines show the direction of water flow from reservoir to pipe or *vice versa,* and arrows drawn with waving lines show the direction of propagation of the pressure wave.

Thus, in the uppermost space we have a *waving* arrow pointing to the *right,* and a *straight* arrow pointing to the *left,* indicating that, during the period between the two moments represented by the first and second figures, respectively, the *pressure wave* is traversing the pipe *from the gate toward the origin,* while *water* is flowing in the opposite direction, viz, *from the large main into the pipe.*

It will be noticed that we always find *normal* pressure between the head of the wave and the *origin,* and *abnormal* pressure between the head of the wave and the *gate;* in other words, that disturbances of pressure come always from the gate and the restoration of normal pressure comes always from the origin. Hence, the pressure at any point remains normal so long as the head of the pressure wave (moving in either direction) is between such point and the gate; and the nearer the point is to the origin, the longer will be its periods of normal and the shorter its periods of supernormal and subnormal pressure, and *vice versa.*

Formula for the Velocity, λ, of the Pressure Wave.

The formula for the velocity, λ, of propagation of the pressure wave was deduced by Joukovsky, by means of a purely deductive mathematical analysis, from the differential equation representing the phenomenon of water hammer.

This formula is:

$$\lambda = \frac{1}{\sqrt{\frac{\gamma}{Kg} + \frac{2R_0\gamma}{eEg}}} = \frac{1}{\sqrt{\frac{\rho_0}{K} + \frac{2R_0\rho_0}{eE}}},$$

where

$2\,R_0$ = the diameter of the pipe.

e = the thickness of the walls of the pipe.

E = Young's linear modulus of elasticity of the material of the pipe,

$= \frac{\text{unit stress}}{\text{unit stretch}}$,

= 1,000,000 kilograms per square centimeter for cast iron.

= 10^{10} kilograms per square meter for cast iron.

K = the volumnar modulus of elasticity of water.

= 21,000 atmospheres.

= 300,000 pounds per square inch.

γ = the weight of a unit of volume of water.

g = the acceleration of gravity.

$\rho_0 = \frac{\gamma}{g}$ = the density (mass per unit of volume) of water.

As already mentioned, this formula for the velocity of the pressure wave fully coincides with Korteveg's formula for the velocity of sound waves in an elastic pipe filled with a compressible liquid.

Korteveg's formula is:

$$\lambda = \frac{\lambda_1 \lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}},$$

where

λ_1 = the velocity of the sound wave in an inelastic pipe filled with a compressible liquid.

This velocity is

$$\lambda_1 = \sqrt{\frac{Kg}{\gamma}} = \sqrt{\frac{K}{\rho_0}} \;.$$

For water, $\lambda_1 = 1435$ meters per second $= 4711$ feet per second.

λ_2 is the velocity of the pressure wave in an elastic pipe filled with an incompressible liquid. This velocity, as given by Resal in discussing the pulsation of the blood in the arteries of animals, is

$$\lambda_2 = \sqrt{\frac{eE}{2R_0\rho_0}} = \sqrt{\frac{eEg}{2R_0\gamma}} \;.$$

Substituting these values of λ_1 and λ_2 in the formula of Korteveg, we obtain exactly the formula deduced by Joukovsky for the velocity of the pressure wave in an elastic pipe filled with an elastic liquid.

Applying this formula, Joukovsky calculated the theoretical value of λ for the pipes used in his experiments,* obtaining the values given in the following table, in which all the steps of the calculation are shown.

The formulæ of Joukovsky being entirely rational, and not empirical, any system of units may be used at pleasure, care being taken, of course, to adhere to one and the same system of units throughout any one equation.

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* In all the experiments of Joukovsky these were cast-iron waterworks pipes, of the type standardized by the Russian Waterworks Conventions. For pipes where E or $\frac{e}{R_0}$ differs from the corresponding value for these pipes, other results will be obtained.

TABLE I.

TABLE OF THEORETICAL CALCULATION OF λ FOR THE PIPES USED IN THE EXPERIMENT OF JOUKOVSKY.

$2 R_0$, Diameter of the Pipe, Inches.	e, Thickness of Walls of Pipe, Inch.	$\sqrt{\frac{e}{2 R_0}}$	For Cast Iron, $\sqrt{\frac{E g}{\gamma}}$ Feet per Second.	$\lambda_1 = \sqrt{\frac{K g}{\gamma}}$. Feet per Second.	$\lambda_2 = \sqrt{\frac{e}{2 R_0}} \times \sqrt{\frac{E g}{\gamma}}$ Feet per Second.	λ, feet per Second. $\lambda = \frac{\lambda_1 \lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}} = \frac{1}{\sqrt{\frac{\gamma}{K g} + \frac{2 R_0 \gamma}{e E g}}}$	λ, feet per Second. λ Obtained from the Experiments. (See pp. 383, 384, 387.)
1	2	3	4	5	6	7	8
2	$\frac{10}{32}$	$\frac{1}{8}\sqrt{10}$	$\sqrt{\frac{10^{10} \times 9.8}{1000 \times 0.3048^2}} = 32479$	$\sqrt{\frac{21012 \times 10000 \times 9.8}{1000 \times 0.3048^2}} = 4710$	12838	4424	4375
4	$\frac{11}{32}$	$\frac{1}{8}\sqrt{\frac{11}{2}}$			9520	4228	4200
6	$\frac{13}{32}$	$\frac{1}{8}\sqrt{\frac{13}{3}}$			8449	4116	4100
24	$\frac{22}{32}$	$\frac{1}{8}\sqrt{\frac{11}{12}}$			3885	2996	3313

Formula for the Maximum Additional Pressure, P, Produced by the Closure of the Gate.

Joukovsky found that

$$P = \frac{v\lambda\gamma}{g} = v\lambda\rho_0 ,$$

where

v = the extinguished velocity of water in the pipe.
λ = the speed of propagation of the pressure wave in the pipe.
γ = the weight of a unit volume of water.
g = the acceleration of gravity.
$\rho_0 = \frac{\gamma}{g}$ = mass of unit of volume of water = its density.

Joukovsky gives two different methods of deduction of this formula. One of these methods is based upon the equation of the conservation of energy; the other upon a mathematical expression of the fact that the space, vacated by the compression of the water and the stretching of the pipe, always equals the volume of water which arrives during the same time with the given velocity, v, to fill said space.

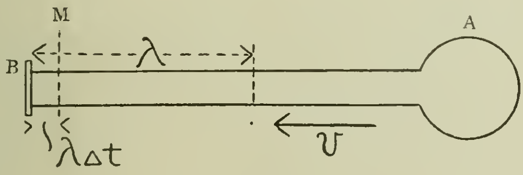

FIG. 8.

We now give this second method of deducing the formula:

Let us suppose that water is flowing, with velocity v, through the pipe, A B, Fig. 8. The gate B is now suddenly closed and the flow is stopped, the stoppage proceeding from the gate through the whole length of the pipe with velocity λ per second. In other words, during the first second, following the moment of closure of the gate, a column of water, of length λ, is arrested. Those parts of the water column which are farther from the gate than the length λ will not be stopped during this first second.

During an interval of $\triangle$ t seconds, the stoppage of flow proceeds through a length, B M $= \lambda \triangle$ t, to the point M; compressing the water, stretching the pipe walls, and thus bringing an increase, P, of pressure throughout the length, M B, to the left of M.

In A M, to the right of M, the water is still flowing with the original velocity, v; consequently, during the interval of $\triangle$ t seconds, the cross-section, M, whose area is πR_0^2, has passed a volume of water

$$Q = \pi R_o^2 . v . \Delta t \qquad (1)$$

By virtue of the stretching of the pipe walls, the volume of the pipe, B M, is increased by the quantity

$$q = (\pi R^2 - \pi R_o^2) . \lambda . \Delta t \qquad (2)$$

where

$R_0 =$ the normal inside radius of the pipe.

$R =$ the inside radius of the pipe after it has been stretched by the pressure, which has been increased by P.

But the compression of the water represents a further

volume $$q' = \pi R_o^2 (\lambda \Delta t) \left(\frac{\rho - \rho_o}{\rho_o} \right) \qquad (3)$$

where

$\rho_0 =$ the density of the water before compression.

$\rho =$ the density of the water under the pressure increased by P.

$\frac{\rho - \rho_0}{\rho_0} =$ the relative increase of density of the water.

Now Q and q + q′ are necessarily equal. Hence,

$$\pi R_o^2 v \Delta t = (\pi R^2 - \pi R_o^2)\lambda \Delta t + \pi R_o^2 \left(\frac{\rho - \rho_o}{\rho_o}\right)\lambda \Delta t$$

$$\left.\begin{array}{c}\text{Volume}\\ \text{of water}\\ \text{added}\end{array}\right\} = \left\{\begin{array}{c}\text{Increase of}\\ \text{volume of pipe}\end{array}\right\} + \left\{\begin{array}{c}\text{Space vacated}\\ \text{by compression}\\ \text{of water.}\end{array}\right.$$

$$Q \quad = \quad q \quad + \quad q'$$

Consequently, dividing by $\pi R_0^2 \triangle t$, we find

$$v = \left(\frac{R^2 - R_o^2}{R_o^2} + \frac{\rho - \rho_o}{\rho_o}\right)\lambda = \left(\frac{R - R_o}{R_o} \cdot \frac{R + R_o}{R_o} + \frac{\rho - \rho_o}{\rho_o}\right)\lambda$$

But, R being very nearly $= R_0$, we may substitute 2 for $\frac{R + R_0}{R_0}$;

Hence $$v = \left(2\,\frac{R - R_o}{R_o} + \frac{\rho - \rho_o}{\rho_o}\right)\lambda \qquad (4)$$

Here $\frac{R - R_0}{R_0}$ is the stretch of the pipe, $R - R_0$, per unit of the original radius, R_0, due to the stress in its walls produced by the additional pressure, P, of the water per unit of surface.

On a semicylinder of unit length, this additional pressure gives a resultant force, $P . \overline{KLMN} = P . 2 R_0$ (see Fig. 9), which gives, in the walls, $\overline{KL}$ and $\overline{MN}$, of thickness, e, an additional stress, per unit of cross-section,

$$\frac{2 R_o P}{\text{Sum of Areas } \overline{KL}, \overline{MN}} = \frac{2 R_o P}{2 e} = \frac{R_o P}{e}$$

But $\frac{R_o P}{e} : \frac{R - R_o}{R_o}$ = modulus of elasticity, E, of the pipe walls;

Hence $$\frac{R-R_o}{R_o} = \frac{R_o P}{Ee}.$$

Now $\frac{\rho - \rho_0}{\rho_0}$, being the increase of density per unit of normal density, is numerically equal to the reduction of volume in unit mass caused by the additional pressure, P; and K is the volumnar modulus of elasticity of water.

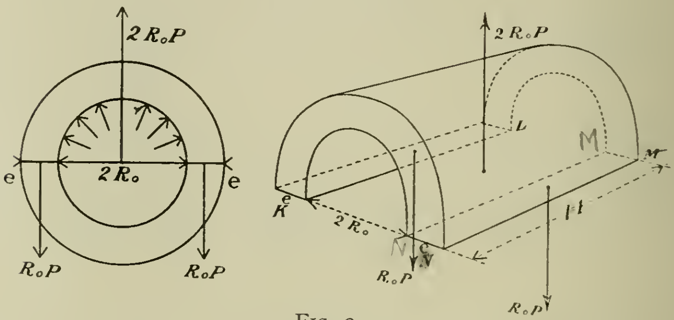

FIG. 9.

Hence $$K = \frac{P}{\frac{\rho-\rho_o}{\rho_o}}; \text{ and } \frac{\rho-\rho_o}{\rho_o} = \frac{P}{K}.$$

Hence, substituting, in equation (4), the values just found for $\frac{R - R_0}{R_0}$ and $\frac{\rho - \rho_0}{\rho_0}$,

$$v = \left(\frac{2 R_o P}{Ee} + \frac{P}{K}\right)\lambda = \frac{P\lambda}{\rho_o}\left(\frac{2 R_o \rho_o}{Ee} + \frac{\rho_o}{K}\right).$$

But (see p. 362) $$\lambda = \frac{1}{\sqrt{\frac{\rho_o}{K} + \frac{2 R_o \rho_o}{Ee}}}.$$

Consequently $$v = \frac{P\lambda}{\rho_o \lambda^2} = \frac{P}{\rho_o \lambda};$$

and $$P = v\lambda\rho_o.$$

Now ρ_0, the original density of the water, is equal to the weight of a unit of volume of water divided by the acceleration of gravity; or

$$\rho_o = \frac{\gamma}{g}$$

Therefore, the maximum additional pressure, caused by water hammer, is

$$P = \frac{v \lambda \gamma}{g} \qquad (5)$$

From this formula (5) we see that *the increase, P, of pressure, stands in direct proportion to the extinguished velocity, v, of flow; that it does not depend on the length of the pipe, and that it is directly proportional to the velocity, λ, of propagation of the pressure wave;* the last-named quantity, being expressed by the formula

$$\lambda = \frac{1}{\sqrt{\frac{\rho_o}{K} + \frac{2 R_o \rho_o}{E e}}},$$

depends on the size, thickness and kind of pipe and on the density and modulus of elasticity of the liquid.

Substituting numerical values in the formula

$$P = h v = \frac{v \lambda \gamma}{g}$$

Joukovsky finds that, for the pipes with which he experimented, each foot per second of extinguished velocity of flow causes an increase of pressure as given in atmospheres in the following table:

TABLE II.*

THEORETICAL VALUES OF ADDITIONAL SHOCK PRESSURE.

$2 R_0$ Diameter of Pipes, in Inches.	$h = \frac{P}{v}$ Additional Pressure, per Foot per Second of Extinguished Velocity of Flow, in Atmospheres.
2	4.066
4	3.886
6	3.783
24	2.754

---

* Here the calculated values of λ (Table I, page 364, column 7) are taken.

From this table we see that, *for pipes of small diameters (2 inches to 6 inches), the increase, h, of pressure, for each foot of extinguished velocity of flow v, equals about 4 atmospheres.*

$$P = 4\,v \text{ atmospheres.}$$

For pipes of large diameters h is somewhat less.

These results, obtained from the formula, correspond well with those obtained during the experiments on the diagrams of the indicators. (See, for instance, the tables on pages 383, 384, 387.)

III. Experimental Proof of the Correctness of Joukovsky's Theory.

1. Maximum additional shock pressure, P, in different points of the pipes, as measured by means of Bourdon manometers.

Eleven Bourdon manometers, with frictional pointers for the marking of the maximum readings, were placed on the 4-inch pipe at different points.

Before the gate was opened, all the frictional pointers were set near the pointers of the manometers, which showed the static pressure in the main, which was equal to 4.5 atmospheres, effective. Then the gate was opened to the desired extent, and water allowed to flow from the pipe, the rate being determined by measurement of the discharge in the tank. Next the weight on the gallows frame was dropped, quickly closing the gate, and the water hammer thus effected. Finally the readings of all the frictional pointers were noted. The results of such experiments, performed upon the 4-inch pipe on June 23 and 24, 1897, are given in Table III, page 371.

TABLE III.

PRESSURE EXPERIMENTS WITH MANOMETERS ON 4-INCH PIPES, JUNE 23, 24, 1897.

No. of Experiment.	Velocity of Water in Feet per Second.	Readings of Manometers in Atmospheres.											Average of Readings of Manometers Nos. 1-10.	Average P.	P According to the Approximate Formula P = 4 v.
		Manometer No.													
	v.	1	2	3	4	5	6	7	8	9	10	11			
1	2	3											4	5	6
1	7.0	40	37	48	37	36	48	38	38	45	38	8	40.5	36.0	28.0
2	7.0	40	40	53	38	42	48	38	38	47	38	8	42.2	37.7	28.0
3	4.7	28	28	29	26	26	38	27	30	27	27	7	28.6	24.1	18.8
4	6.4	28	26	25	25	25	34	27	27	28	26	7	27.1	22.6	25.6
5	2.8	18	15	15	15	15	18	16	17	17	16	5.5	16.2	11.7	11.2
6	2.6	18	14	14	12	13	18	15	15	15	14	5.5	14.8	10.3	10.4
7	9.9	50	50	68	50	52	50	37	44	53	34	7	48.8	44.3	39.6
8	3.5	29	27	29	25	25	37	25	27	27	26	7	27.7	23.2	14
9	4.0	22	23	23	20	22	29	21	24	23	22	6	22.9	18.4	16
10	4.0	25	23	22	20	23	27	21	23	23	22	6	22.9	18.4	16

Looking over the pressures observed at different points of the pipe, we see that *the shock was propagated along the pipe without being weakened.*

Manometer No. 11, standing at the end of the pipe nearest to the main, shows, as might be expected, pressures approaching that of the main; therefore its readings were not included in calculating the averages. The fluctuations, observed in the readings of the manometers, are explained by the inertia of the bent tube of the Bourdon manometer and by the fact that, with high velocities, v, the maximum pointers, arrested by friction, sometimes marked, not the first but the second pressure wave.* The same reasons must be assigned for the fact that the pressure, P, determined from the average of the readings of the manometers, is higher than when calculated according to the formula $P = 4\ v$.

During the experiments with the 2-inch pipe, 11 manometers were used, No. 11 being placed near the main. The results obtained from these experiments on September 1 and 23, 1897, are given in Table IV, page 373.

This table also shows that *the pressure is transmitted undiminished throughout the length of the pipe* (the readings of the tenth manometer, which stood near the end of the pipe, were sometimes even higher than those of No. 1).

For the reasons already given, variations, due to imperfection of the measuring apparatus, are here found, as well as in Table III, page 371. Better results were obtained by means of indicators (see pp. 383, 384, 387.)

2 *Speed of Pressure Wave Propagation, λ, Measured by Means of a Marey Chronograph.*

In order to measure the speed of propulsion of the pressure waves, use was made of a Marey chronograph, which gave readings corresponding to 0.01 second.

---

* The second pressure wave may be greater than the first when two water columns are directed against one another. See pp. 381, 382.

TABLE IV.

Pressure Experiments with Manometers on 2-inch Pipes, September 1 and 23, 1897.

No. of Experiment.	Velocity of Water in Feet per Second.	Readings of Manometers in Atmospheres. Manometer No.											Average of Readings of Manometers Nos. 1–10.	Average P.	P According to the Approximate Formula P = 4 v.
	v.	1	2	3	4	5	6	7	8	9	10	11			
1	2	3											4	5	6
1	4.4	27	23	25	24	30	30	33	32	30	28	5	28.2	23.7	17.6
2	4.4	30	24	25	22	34	30	32	30	32	30	5	28.9	24.4	17.6
3	3.3	20	18	18	20	25	23	28	30	22	24	5	22.8	18.3	13.2
4	3.2	20	18	18	20	20	26	30	32	23	24	5	23.1	18.6	12.8
5	4.5	30	30	20	23	23	20	27	25	35	29	5	26.2	21.7	18.0
6	4.4	25	30	20	25	35	25	27	26	27	30	5	27.0	22.5	17.6
7	4.4	29	30	20	25	35	20	27	26	27	30	5	26.9	22.4	17.6

The observations were made thus: In two points of the 4-inch pipe, at a distance of 700 feet apart along the pipe, two U-shaped manometric tubes were placed, which, at the moment of increase of pressure, unbent and pushed forward metallic rods, controlling electrical contacts. Each rod, after being once pushed out, was held in the new position by means of a spring. The contact made by the first rod (the nearest to the beginning of the pipe) sent an electric current to the Alexeievskaia pump house, where the Marey chronograph was placed. (See Fig. 10.) This current lifted the armature of the chronograph, which

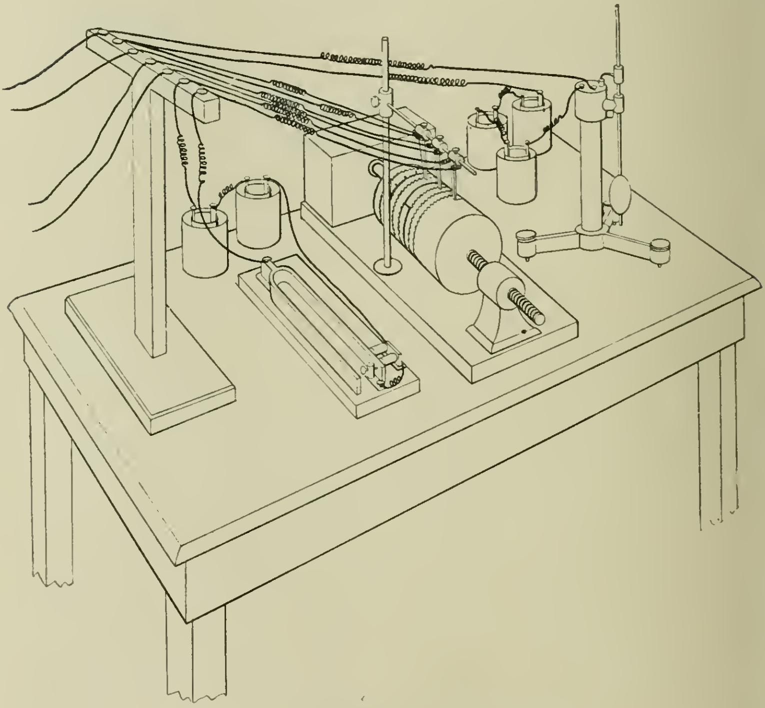

FIG. 10. THE MAREY CHRONOGRAPH.

carried a pen, tracing a diagram on a revolving cylinder covered with blackened paper. At the moment when the pressure wave arrived at the second manometer, similar to the first, it cut off the current (by pushing the rod), and the armature, with the pen, returned to its original position. In this way the pen of the chronograph drew a hump, the length of which, expressed in time units, showed the duration of the 700 feet run of the pressure wave. The time was obtained in hundredths of a second, which were marked on the same cylinder by a wave-like line made by a special pen. This pen was moved by an electric current, interrupted by a tuning fork making 100 vibrations per second.

Fig. 10 shows the chronograph and the tuning fork. The pendulum (also seen in this figure) made an electric contact every half-second, sending a current to the Marey chronograph and to the observation houses containing the Crosby indicators, marking, upon the diagrams, the dots which served to co-ordinate them in time.

Data obtained from these experiments on the 4-inch pipe with the chronograph on June 22 and 24, 1897, are given in the table below.

TABLE V.

OBSERVATIONS FOR VELOCITY, λ, OF PROPAGATION OF PRESSURE WAVE IN 4-INCH PIPE, BY MEANS OF THE CHRONOGRAPH, JUNE 22 AND 24, 1897.

No of Experiment.	Velocity, in Feet per Second.	Duration of a 700 Feet Run, in Seconds.
1	10.8	0.170
2	4.6	0.160
3	3.1	0.140
4	3.5	0.180
5	4.0	0.140
6	3.9	0.160
7	4.1	0.165
8	7.1	0.190
9	9.1	0.180

According to this table, the average 700 feet run of the wave lasted 0.165 second; this corresponds to the velocity $\lambda = \frac{700}{0.165} = 4242$ feet per second, which is quite near to the theoretical velocity calculated by Joukovsky, equal to 4228. (See Table I, page 364.)

Similar observations were performed also with the 2-inch pipe, the manometric apparatus being placed at a distance of 1246 feet apart. In Fig. 2 the locations of the manometers are indicated by square dots. The data obtained from these experiments on September 23, 1897, are given in the following table:

TABLE VI.

OBSERVATIONS FOR VELOCITY, λ, OF PROPAGATION OF PRESSURE WAVE IN 2-INCH PIPE, BY MEANS OF THE CHRONOGRAPH, SEPTEMBER 23, 1897.

No. of Experiment.	Velocity, in Feet per Second.	Duration of a 1246 Feet Run, in Seconds.
1	3.07	0.306
2	1.80	0.302
3	1.80	0.297
4	0.80	0.297
5	1.54	0.300

The average duration of the run of the wave, from one point to the other, 1246 feet, is here = 0.300 second, which gives a velocity $\lambda = \frac{1246}{0.300} = 4153$ feet per second for the 2-inch pipe. This velocity is less than the theoretical 4424 feet per second (see Table I, page 364), and even less than that in the 4-inch pipe, whereas, according to the calculations, the velocity in the 2-inch pipe should be the greater.

Joukovsky suggests that this discrepancy may be due to residual magnetism in the armature of the Marey chronograph.

Other observations (pages 383, 384), performed by means of a more accurate method (p. 382), have shown that, in the 2-inch pipe, λ is a little greater than in the 4-inch pipe, as it should be also according to the calculation.

3. Determination of λ and P by Means of Crosby Indicator Diagrams.

(a) The diagrams and the method of obtaining them.

The Crosby indicators were placed in portable houses I, II, III. House I stood always near the gate, g (Fig. 2), while II and III were placed on the pipe line to be tested, usually at one-third and two-thirds of its length.

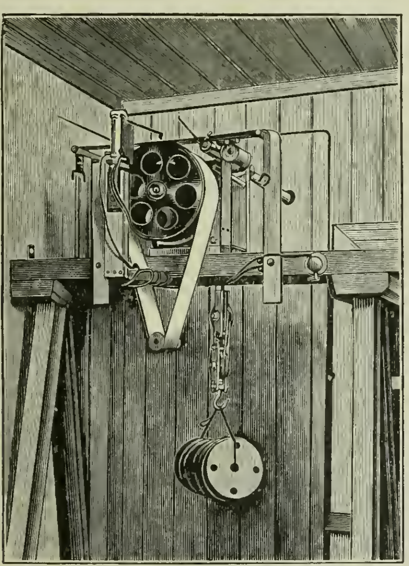

FIG. 11. THE CROSBY INDICATOR.

Fig. 11 shows the interior of one of these houses, with the Crosby indicator used in these experiments. The pressure cylinder of the indicator, with its piston and springs, was identical with the ordinary steam engine indicator; but the arrangement for moving the paper was a special one, constructed by Mr. Oldenborger. It consisted of a cylinder of about 8 inches diameter, with horizontal axis, revolved by means of a weight-driven mechanism; a band of paper was placed over the cylinder, and held in tension by the weight of a roll, placed in the loop, as shown. On this band a dot was made every half-second, through a typewriter ribbon, by the pointer shown, which was actuated by a current governed by the pendulum in the pump house.

The pressure cylinder of the indicator was connected with the water pipe by means of a small metal tube.

Strong springs were used, in order to diminish, as far as possible, the agitation of the indicator pencil by inertia.

The observations were performed as follows: Upon electric signals from the observer in house I, the observers in houses II and III took the atmospheric, the hydrostatic and the hydrodynamic pressure, each being represented by a horizontal line traced by the pencil of the Crosby indicator.

While the line of hydrodynamic pressure was being traced, the velocity of flow was determined by means of the measuring tank.

The observer at house I then closed the circuit operating the apparatus for making simultaneous half-second marks on the revolving paper in the three houses, and gave the order to close the gate by means of the falling weight. Starting from this moment, the pencils of the indicators in the three houses traced the diagrams of pressure of water hammer.

Samples of diagrams obtained are given in Figs. 4 and 5.

The first curve on Fig. 4 was obtained in house I, at the gate; the second in house II. The diameter of the pipe was 6 inches, the velocity of flow, $v = 0.64$ feet per second. The points under the curves indicate the time in half-seconds.

We see that the shape of the curves is different in the two cases, and in their general form these contours fully agree with the theoretical curves shown in Fig. 3.

Fig. 5 shows curves simultaneously obtained in houses I, II and III with a 2-inch pipe, velocity, v = 1.8 feet per second, and water-hammer pressure P = 7 atmospheres. We see that the first curve consists only of an upper step, the second of a long upper step and a short middle step, and the third of a short upper step and a long middle step. Expressed in time units, the distance between the commencement of increase of pressure to the higher step and the commencement of its falling below this step must be equal, on each of the curves, to a round trip of the pressure wave from the point of observation to the main. During the observation the distances between the main and the points of observation were in the ratio of 3:2:1. The lengths of the higher steps of the curves of the diagrams are also in the ratio of 3:2:1.

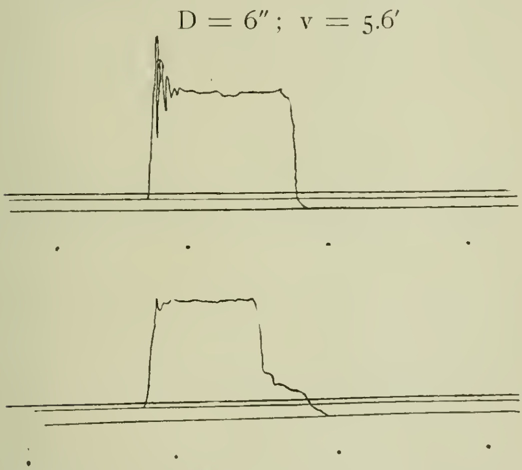

Fig. 12. Indicator Diagrams in Two Points of the 6-inch Pipe.

Fig. 12 gives diagrams, obtained in houses I and II,

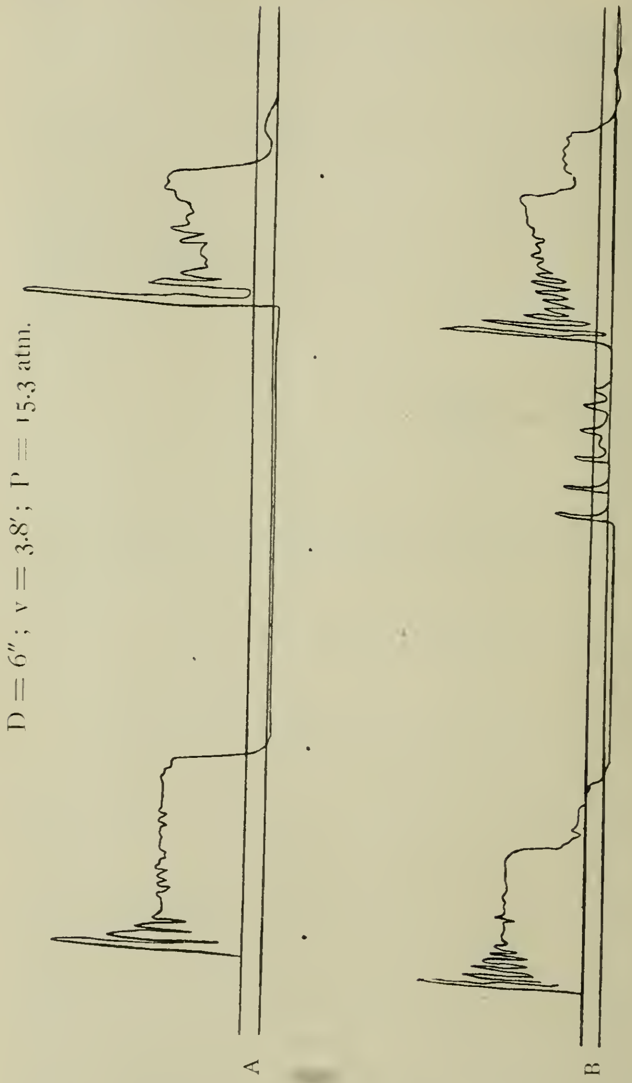

FIG. 13. INDICATOR DIAGRAMS, SHOWING THE EFFECT OF SEPARATION OF WATER COLUMN.

with a 6-inch pipe, velocity, $v = 5.6$ feet per second, and water-hammer pressure $= 25$ atmospheres.

The curves of the first increase of pressure are generally in complete accordance with the theory in cases of both small and great velocities of flow, and they enable us to determine the values of the velocity, λ, of propagation of the pressure wave, and of the additional pressure, P, due to water hammer.

The violent fluctuations, shown at each sudden increase of pressure, are attributed by Joukovsky to the effect of the small pipe leading to the Crosby indicator, which acted as a dead end (see page 387), momentarily increasing the pressure in the pipe, special care having been taken to minimize the effect of inertia in the moving parts of the apparatus.

The irregular shape of the middle step of the second curve is caused by the increase of pressure in the main itself, due to the arrival of the wave at the origin. This increase made the middle step higher than normal.

The curve of Fig. 13, A, was obtained in house I, which stood near the gate on the 6-inch pipe. The velocity of flow was 3.8 feet per second, and the shock pressure 15.3 atmospheres. It will be noticed that the lowest step of this curve is much longer than the upper step; also that the second rise of the curve begins with a violent oscillation, which runs higher than that of the first rise.

The same peculiarities characterize Fig. 13, B, which was obtained in the same experiment in house II. Moreover, in this case, in that part of the diagram where the middle step of static pressure should appear, we see a number of small separate peaks never observed on the curves obtained at house I.

Joukovsky believes that these eccentricities are due to the fact that, in this experiment, the subnormal pressure fell below the atmospheric pressure, as shown in the diagrams. This caused a parting of the water column and some disengagement and possible inhalation of air and liberation of water vapor, and this combined column of water, air and vapor occupied a longer time for its movements than would normally be the case. This accounts for the length of the portion of the diagram occupied by the curve of subnormal pressure; and the separate shocks, due to collisions between the several portions of the broken column, and their increased velocities when rushing into the partial vacuum formed, explain the irregular character of that part of the curve representing the second rise of pressure.

Joukovsky notes that the portion of the curve which represents the first period of supernormal pressure, and which was obtained while the whole column was under constant pressure, and before the sub-atmospheric pressure had appeared, was very regular, and served perfectly for the determination of the velocity, λ, of propagation of the pressure wave.

The determination of the velocity, λ, from the pressure diagrams was based on the fact that, during every cycle, the pressure wave makes two round trips through the pipe. (See page 359.) The time of a round trip was measured along the horizontal axis of the diagrams, taking, as a scale, the distances between the half-second points marked by the pendulum (the large scale of the diagrams could be read to hundredths of a second). Knowing the length of the pipe through which the wave traveled, it was easy to find the velocity.

The additional pressure, P, was determined from the diagrams by measuring the height of the first rise of the pressure curve above the line of hydrodynamic pressure; the scale was determined by the elasticity of the spring used in the indicator.

The following tables give the record of the experiments on the 2, 4, 6 and 24-inch pipes, and the values obtained for velocity, λ, and pressure, P.

TABLE VII.

(*b*) Observations of Wave Velocity, λ, and Pressure, P, in a 2-inch Pipe, by Means of Indicators, September 23, 1897.

No. of Experiment.	Velocity of Water in Feet per Second.	Duration of Round Trip of Wave in Seconds.					Duration of Gate Closure in Seconds.	P in Atmospheres.			
		From the Gate to the Origin.			From House II to the Origin.	From House III to the Origin.		From Diagrams.			Calculated P = 4 v.
	v.	House I.	House II.	House III.			T	House I.	House II.	House III.	
1	2	3	4	5	6	7	8	9	10	11	12
1	4.52	1.16	1.15	1.15	0.77	0.38	0.08	18.5	18.0	18.0	18.1
2	4.30	1.13	1.15	1.15	0.78	0.39	0.06	17.8	17.5	16.7	17.2
3	4.16	1.14	1.13	1.13	0 78	0.40	0.06	17,0	16.6	16.0	16.6
4	3.67	1.15	1.13	1.13	0.76	0.37	0.06	15.1	15.0	14.5	14.7
5	3.67	1.14	1.13	1.14	0.75	0.40	0.05	14.5	14.4	14.6	14.7
6	3.66	1.14	1.13	1.13	0.76	0.39	0.06	14.6	14.6	15.0	14.6
7	1.79	1.14	1.14	1.13	0.76	0.39	0.05	6.3	5.9	6.3	7.2
8	1.76	1.14	1.14	1.13	0.76	0.39	0.06	7.3	7.3	7.2	7.0
9	0.64	1.14	1.15	1.14	0.75	0.39	0.06	2.8	2.8	2.5	2.6
10	1.52	1.14	. .	1.15	. .	0.39	0.05	6.3	6.3	6.3	6 1
11	1.52	1 13	1.13	1.13	0.75	0.38	0.06	6.3	6.3	6.1	6.1
12	4.23	1.14	1.13	1.13	0.76	0.39	0.07	17.3	16.7	16.1	16.9

The length of the 2-inch pipe was 2494 feet.
The pressure wave made a round trip through this pipe in 1.14 seconds.
Hence, the velocity of the pressure wave in a 2-inch pipe is

$$\lambda = \frac{2494 \times 2}{1.14} = 4375 \text{ feet per second.}$$

The calculated value of λ for a 2-inch pipe is 4424 feet per second. (See Table I, page 364.)

In this experiment the distances of houses I, II, III from the origin being equal to 2494, 1640, 822 feet were proportional to 3 : 2 : 1; and we see that the durations of round trip of wave from these houses to the origin, being equal to 1.14, 0.78, 0.39 seconds, are in the same proportion.

TABLE VIII.

(*c*) OBSERVATIONS OF WAVE VELOCITY, λ, AND PRESSURE, P, IN A 4-INCH PIPE, BY MEANS OF INDICATORS, NOVEMBER 4, 1897.

No. of Experiment.	Velocity of Water in Feet per Second, v.	Duration of a Round Trip of Wave in Seconds.			Duration of Gate Closure in Seconds, τ	P in Atmospheres.		
		House I.	House II.	Average from a Number of Cycles.		From Diagrams. House I.	From Diagrams. House II.	Calculated P = 4 v.
1	2	3	4	5	6	7	8	9
1	3.3	0.49	0.51	. .	0.04	13.3	13.3	13.2
2	1.9	0.50	0.50	. .	0.04	7.8	7.8	7.6
3	4.1	0.49	0.50	. .	0.03	15.8	15.9	16.4
4	9.2	0.49	0.50	. .	0.04	35.0	35.9	36.8
5	2.9	0.49	0.50	. .	0.05	11.3	11.3	11.6
6	0.5	0.50	0.50	0.50	0.04	2.0	2.5	2.0
7	1.1	0.50	0.49	0.51	0.04	4.4	4.3	4.4

The length of the 4-inch pipe was 1050 feet.
The pressure wave made a round trip through this pipe in 0.50 second.
Hence, the velocity of pressure wave in a 4-inch pipe is

$$\lambda = \frac{1050 \times 2}{0.50} = 4200 \text{ feet per second.}$$

The calculated value of λ for a 4-inch pipe is 4228 feet per second. (See Table I, page 364.)

TABLE IX.

(*d*) OBSERVATIONS OF WAVE VELOCITY, λ, AND PRESSURE, P, IN A 6-INCH PIPE, BY MEANS OF INDICATORS, NOVEMBER 20, 1897.

No. of Experiment.	Velocity of Water in Feet per Second, v.	Duration of a Round Trip of Wave in Seconds.			Duration of Gate Closure in Seconds, τ.	P in Atmospheres.		
		House I.	House II.	Average from a Number of Cycles		From Diagrams. House I.	From Diagrams. House II.	Calculated P = 4 v.
1	2	3	4	5	6	7	8	9
1	3.3	0.52	. .	0.52	0.03	15.7	15.7	13.2
2	1.9	0.52	0.52	0.52	0.03	7.3	7.1	7.6
3	0.6	0.52	0.52	0.52	0.04	3.0	3.0	2.4
4	1.4	0.51	0.52	0.52	0.04	6.0	6.1	5.6
5	3.0	0.52	. .	0.52	0.03	12.1	11.44	12.0
6	4.0	0.51	0.51	0.52	0.03	15.6	15.2	16.0
7	5.6	0.52	0.52	0.51	0.04	25.2	25.2	22.4
8	7.5	0.51	. .	0.53	0.04	29.0	29.0	30.0
9	7.5	0.51	Pipe burst.			11.7	11.3	30.0

The length of the 6-inch pipe was 1066 feet. The pressure wave made a round trip through this pipe in 0.52 second.

Hence, the velocity of pressure wave in a 6-inch pipe is

$$\lambda = \frac{1066 \times 2}{0.52} = 4100 \text{ feet per second.}$$

The calculated value of λ for a 6-inch pipe is 4116 feet per second. (See Table I, page 364.)

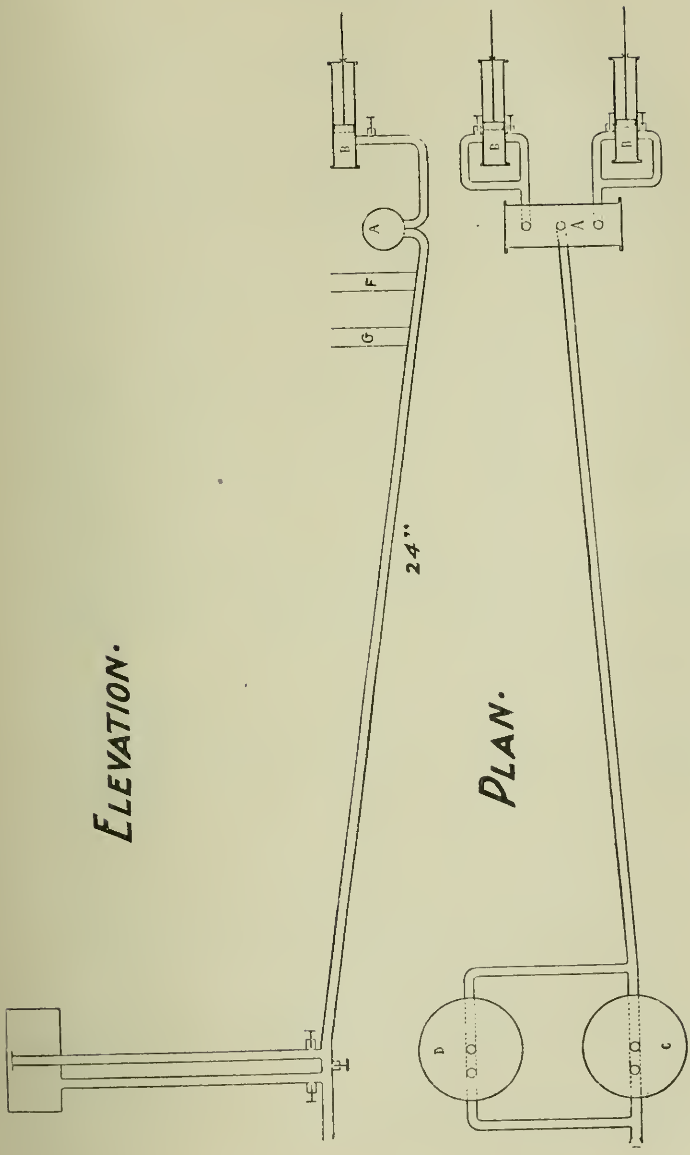

Fig. 14. The 24-inch Main, Used for Experiments.

(*c*) *Observations of Wave Velocity, λ, and Pressure, P, in the 24-inch Main, by Means of an Indicator.*

The 24-inch main (see Fig. 14), upon which the observations were performed, was at that time the chief main of the waterworks of Moscow, leading from the Alexeievskaia pumping plant to the Krestovsky water towers. Its length, from the gate valve (where the water hammer was effected) to the Krestovsky water towers, was 7007 feet; the length of the pipe, between the gate valve and the air chamber in the pump house, was 210 feet.

During the observations the pumps were separated from the pipe by a gate, and the air chamber, filled with water, remained in connection with the pipe, precautions being taken to drive out all the air. The water flowed from the Krestovsky reservoir. The water hammer was produced by means of the same gate as before. The indicator, placed in house I, was connected with the 24-inch pipe near the gate. Weaker springs were used in the Crosby indicator than in the other experiments. The pendulum marked on the indicator not each half-second, as before, but each full second.

Some moments after the dropping of the weight which closed the gate, the pressure wave arrived at the water chamber, compressing the water there, and the pressure was gradually propagated along the 24-inch main, the water gradually coming to rest.

Under these conditions no sudden increase of pressure was recorded on the diagrams, and the shape of the curve, Fig. 15 (because of the influence of the water chamber), was the same as if the gate had been closed gradually.*

Omitting the formula and the theoretical explanation of Joukovsky referring to the influence of the water chamber, we give on page 387 a table of some of the results obtained July 25, 1897:

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* See pages 392-397.

TABLE X.

OBSERVATIONS OF WAVE VELOCITY, λ, AND PRESSURE, P, IN A 24-INCH PIPE, BY MEANS OF INDICATORS, JULY 25, 1897.

No. of Experiment.	Velocity of Water in Feet per Second, v.	Duration of Round Trip of Wave in Seconds.	P in Atmospheres.	
			From Diagrams.	Calculated $P = 3v$.*
1	2	3	4	5
1	0.18	. .	0.45	0.54
2	0.56	4.24	1.81	1.68
3	0.55	4.39	1.66	1.65
4	0.54	4.20	1.77	1.62
5	0.55	4.18	1.80	1.65
6	0.41	4.20	1.23	1.23
7	0.40	4.18	1.27	1.20
8	0.16	. .	0.42	0.48
9	0.16	. .	0.42	0.48
10	0.09	. .	0.29	0.27

The length of the 24-inch main from the gate to the reservoir was 7007 feet.

The pressure wave made a round trip through the pipe in 4.23 seconds. (average).

Hence, the velocity of pressure wave in the 24-inch main is

$$\lambda = \frac{7007 \times 2}{4.23} = 3313 \text{ feet per second.}$$

The calculated value of λ for a 24-inch pipe is 2996 feet per second. (See Table I, page 364.)

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* Using the formula $P = h\,v$, we take here $h = 3$; this value corresponds to $\lambda = 3313$ feet per second, as obtained from these experiments. The value, $h = 2.7$, as given for a 24-inch pipe on page 369, corresponds to the calculated value of λ.

IV. MISCELLANEOUS PHENOMENA CONNECTED WITH WATER HAMMER.

1. *Increase of the Intensity of Water Hammer in Case of Passage of the Pressure Waves into Smaller Pipes with Dead Ends.*

A doubling of water-hammer pressure occurs when the pressure wave is reflected from a dead end of a branching pipe.

Observations in this connection were made upon the passage of the pressure waves from a 4-inch into a 2-inch

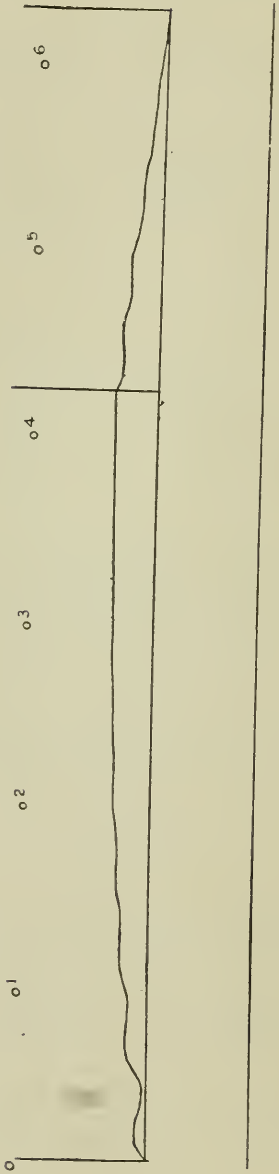

Fig. 15. Indicator Diagram Obtained on the 24-inch Main.

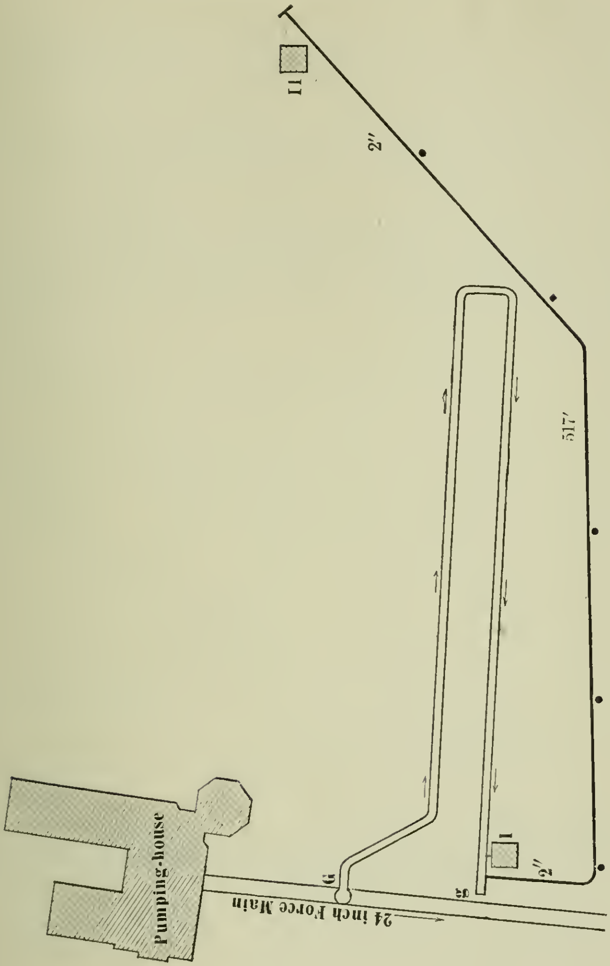

Fig. 16. Dead Ends, Experimental Pipings.

pipe. For this purpose that portion of the 2-inch pipe line was used which was located between houses I and II. (See Fig. 16.) The length of this section was 517 feet, and it was connected, near house I, with the end of the 4-inch pipe, 1050 feet long, which was left, as before, connected with the outlet gate valve and with the indicator of house I. The tube leading to this indicator started from the 4-inch pipe near the point of its connection with the 2-inch pipe. The end of the 2-inch pipe was connected with the indicator of house II and terminated in a gate.

Before the beginning of the observations, water was allowed to flow from this gate, in order to make sure that there was no air in the 2-inch pipe. Then the gate was closed, so that the branch formed a dead end. The gate valve of the 4-inch pipe was then opened, and water let out from it in the usual way; the quantities of water were measured, and the hydrodynamic pressures recorded in houses I and II (near the beginning and at the end of the 2-inch pipe). Then the weight (closing the gate, at the outlet of the 4-inch pipe) was dropped, and the pressure diagrams recorded.

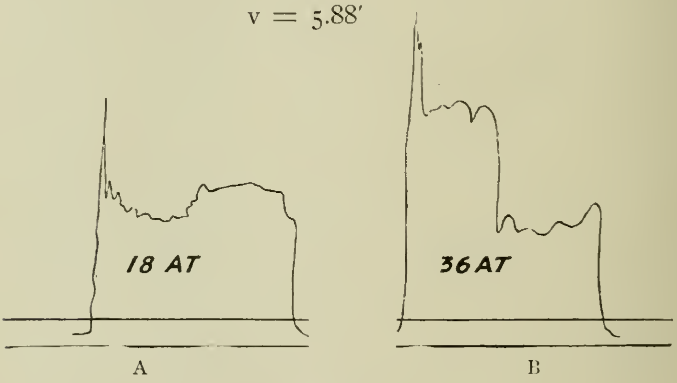

Fig. 17. Indicator Diagrams in the Case of a Dead End.

From the principles already established, Joukovsky concluded that the shock pressure in the small pipe, after and owing to the reflection of the pressure wave from the dead end, would be double that in the large pipe; and this was confirmed by the results of the experiments. For instance, with a velocity of 5.88 feet per second in the 4-inch pipe, the observed pressure in the 4-inch main was 18 atmospheres, while that in the 2-inch pipe was 36 atmospheres. See Fig. 17, where diagram A was taken in house I on the 4-inch pipe and diagram B was taken in house II on the 2-inch pipe.

Similar experiments were afterward made upon the 2-inch pipe connected with the 6-inch pipe. Here also the experiments sustained Professor Joukovsky's conclusion that the pressure would be doubled in the dead end of the small pipe.

The pressure in the larger pipe is increased when the doubled pressure arrives from the dead end, and if this occurs at a moment when the pressure in the large pipe is still supernormal, a very high pressure may result.

If there is a system of several dead ends, as for instance in Fig. 18, a combination of their increased pressures may raise the pressure in the pipe to a dangerous extent. As will be shown below,* the increase of pressure may be totally prevented by the use of safety valves.

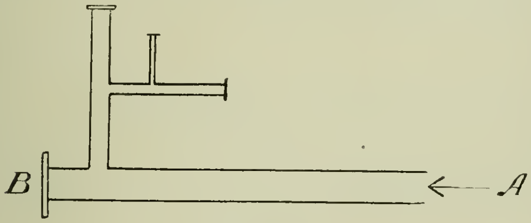

Fig. 18.

2. *Reflection of the Pressure Wave from the Open End of a Discharging Branch Pipe.*

For these experiments the same combination of 2-inch and 6-inch pipes was used as before (Fig. 16); but the gate at the end of the 2-inch pipe was kept open, the water flowing out from it during the entire experiment.

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* See page 413.

At first the gate at the end of the 6-inch pipe was opened, and its discharge was measured. Then this gate was suddenly closed, and the pressure diagrams were recorded in house I. These showed that, so far as the transmission of the pressure wave is concerned, the phenomena, in the flowing water in the branch pipe, follow the laws already established for a pipe in which the flow is checked.

The reflection of the wave from the open end of the 2-inch pipe takes place as it would if this end discharged into a shallow reservoir of water, subjecting the discharge only to atmospheric pressure, which, in this case, is the "normal" (main or reservoir) pressure. Hence the pressure is not doubled (as in the case of a dead end), but diminished.

With the 6-inch and 2-inch pipes described, the pressure in the larger pipe, after the arrival of the reflected wave from the open end of the branch pipe, was about 90 per cent. of the maximum.

3. *Intensity of Pressure as Affected by Length of Time Occupied in Closing the Gate.*

Water hammer may be almost, if not entirely, obviated by closing the gate slowly.

As this subject is one of considerable practical importance, it will be well to examine, with some care, the underlying principles.

Let

t = duration of closure of the gate.
v = velocity of flow of water.
h = pressure obtained per unit of extinguished velocity, v.
$v\,h = P$ = the full maximum shock pressure.
P' = the permissible shock pressure.
l = length of the pipe line.
λ = velocity of the propulsion of the pressure wave.

Let us express in diagrams the successive changes of pressure which we should expect in different points of a pipe line in case of water hammer.

Suppose a pipe, A B (Fig. 19), of length l, which the pressure wave, with velocity, λ, traverses during a time, $t = 8$ seconds $= \frac{1}{\lambda}$ and $l = \lambda t$. For instance, if $\lambda = 1$ kilometer per second, then the length of the pipe will be $l = \lambda t = 1 \times 8 = 8$ kilometers.

In the pipe A B (Fig. 19), let A be the reservoir (or large main from which the pipe is fed) and B the gate, the closing of which produces the water hammer; and let a manometer gauge be placed at the point marked 2, distant 2 kilometers from the gate B.

First, let us suppose that the total closure consists of 8 instantaneous partial closures, 1 second apart, each shutting off abruptly one-eighth of the area of the pipe opening, the first partial closure occurring at the end (1) of the first second, and the last, or eighth, at the end (8) of the eighth second.

Each of these 8 partial closures sends its own weak pressure wave through the pipe, each such wave following exactly the laws already laid down for the case of instantaneous closure, and thus produces a diagram of its own. These diagrams are represented in the upper part of the figure.

Summing up, algebraically, the several partial pressures for the several waves, at each second, as given in the upper diagram, we obtain the influence diagram (covering all the waves) for point 2, as given in the lower figure.

In the same way were obtained the influence diagrams for the other points, given in Fig. 20, B.* The several

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* Where our supposed series of abrupt partial closures is replaced by a gradual closure, in which equal areas are shut off in equal times, the broken diagrams are, of course, replaced by straight lines.

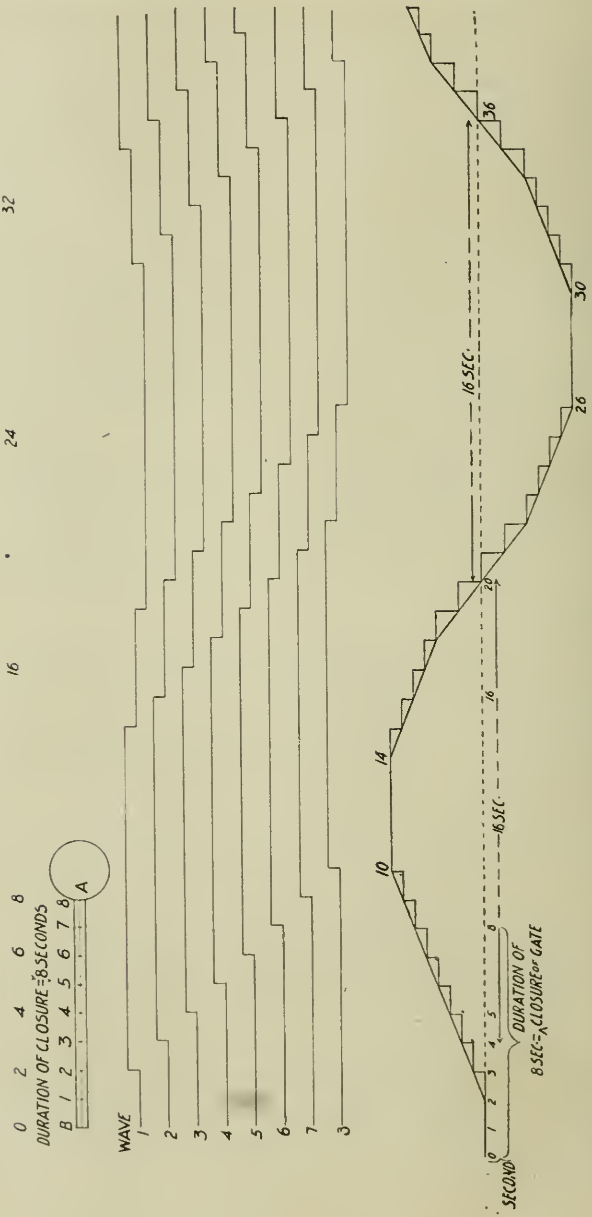

Diagram for Point 2 of the Pipe.

Fig. 19. Pressure Diagrams in the Case of Slow Closure of the Gate.

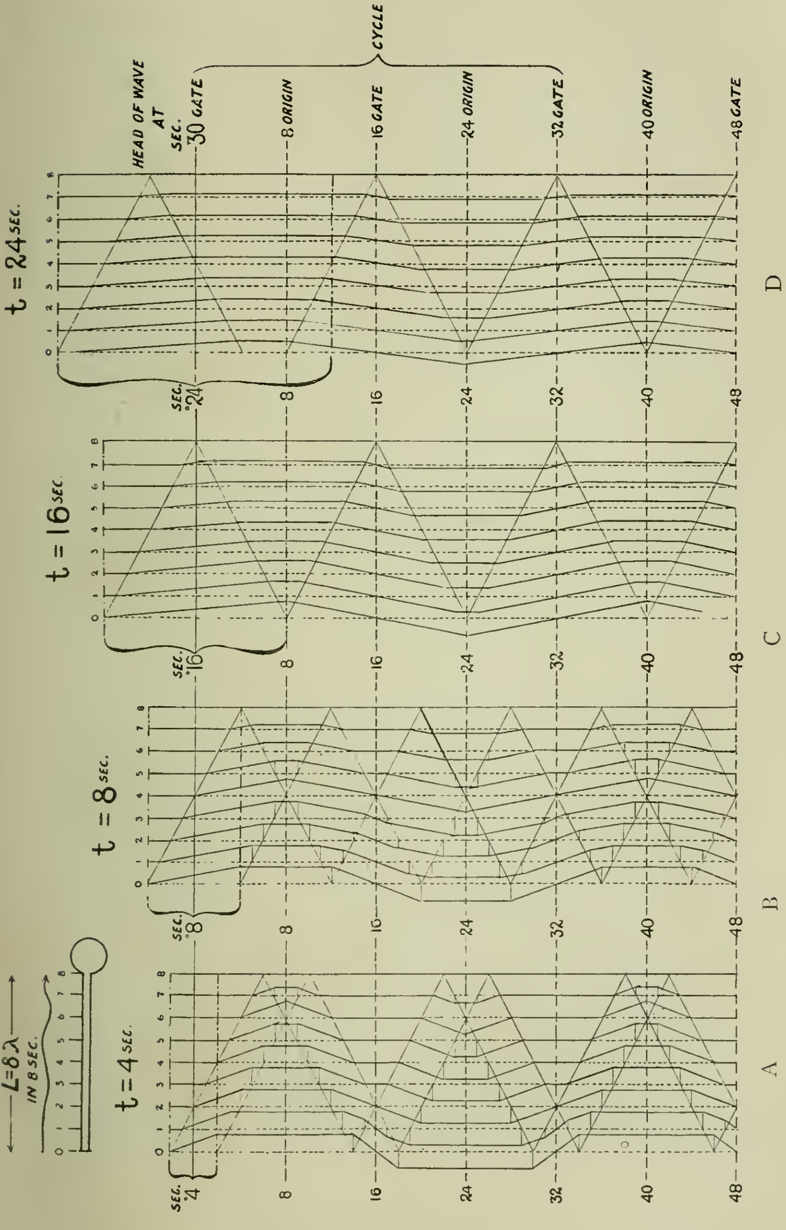

Fig. 20. Pressure Diagrams in the Case of Slow Closure of the Gate.

sets of diagrams (A, B, C, D) of Fig. 20 show the effect of varying the time occupied in closure. In each set pressure diagrams for eight points taken in equal distances along the pipe are traced.

A comparison of the several diagrams in Fig. 20 shows:

1. That the first increase of pressure, due to a uniform closure of the gate in t seconds, proceeds at the rate $\frac{P}{t}$, and that subsequent changes of pressure, at points whose distance from the gate is such that the time required for a round trip of the wave from the point to the gate and back is not less than t, proceeds at the same rate $\frac{P}{t}$; whereas, at the gate, the changes of pressure (after the first increase) proceed at *double* this rate, or rate $= 2\frac{P}{t}$; and at all intermediate points the total change is made partly at the rate $\frac{P}{t}$ and partly at the rate $2\frac{P}{t}$. (See Fig. 20, A, diagram for point 1.)

2. That the maximum shock pressure reaches its full value, P, only at points so far distant from the origin that the time, required for the round trip of the wave from the point to the origin and back, is longer than the time, t, occupied in closing the gate.

Thus (see figures) if $t = 8$ seconds, the full maximum pressure, P, is felt (for an instant only) at point 4, whence the wave travels to the origin and back in 8 seconds $= t$.

3. That from the last point at which the full maximum pressure, P, arrives (for an instant only), the maximum pressure, P′, actually exerted, diminishes uniformly from $P' = P$, at said point, to $P' = 0$, at the origin. In other words, at any point in this portion of the pipe, P′ is less than P in the same proportion as the time, t_r, required for

a round trip of the wave from said point to the origin and back, is less than t; or $P' = P \frac{t_r}{t}$

Hence $$t = t_r \frac{P}{P'}$$

But $t_r = \frac{2l_r}{\lambda}$* and P = h v.

Hence $$t = \frac{2l_r}{\lambda} \cdot \frac{hv}{P'}$$

For a point at the gate, $l_r = l$,

$$t = \frac{2l}{\lambda} \cdot \frac{hv}{P'} .$$

This gives the minimum time, t, which must be occupied in closing the gate, if the shock pressure is not to exceed the permissible pressure, P′, in any point of the pipe.

$$\text{If } t \geqq \frac{2l}{\lambda}\text{; then } \frac{P}{P'} \geqq 1\text{; or } P \geqq P'.$$

Hence we see:

4. That if the time, t, occupied in closing the gate, is not greater than the time, $\frac{2l}{\lambda}$, required for a round trip of the wave from the gate to the origin and back, the full maximum pressure, P, will be felt in some part or all of the pipe, and not otherwise.

4. *Efficiency of Air Chambers in Reducing Water Hammer.*

As already shown by the experiments with the 24-inch pipe,† the effect of a large water chamber, placed at the end of the pipe line (near the gate), is analogous to that due to a prolongation of the time of closing the gate valve.

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* l_r = distance from the point in question to the origin.

† See page 386.

The effect of an air chamber is quite similar, but much more considerable. Joukovsky placed an air chamber on the 2-inch experimental pipe between houses II and III, at a distance of 1070 feet from the gate. (See Fig. 2.) Air chambers of different volumes were used for experiments. The gate was closed in the usual way, and pressure curves were recorded in each of the three houses; the most interesting, however, were those obtained in houses I and III.

Figs. 21 and 22 show curves obtained with a small air chamber (about 60 cubic inches), the velocity being 4.4 feet per second. The curve in Fig. 21 was obtained in house I, between the gate and the air chamber, while that in Fig. 22 was obtained in house III, between the air chamber and the origin. We see, from the curves, that an air chamber of that small size caused no lowering of the first stage of the curve obtained between the gate and the air chamber, which showed a pressure of 17.3 atmospheres, which is very nearly equal to the theoretical P = h.v = 4 atmospheres × 4.4 = 17.6 atmospheres. As to the second stage of this curve, the air chamber even *increased* the pressure, in the second stage, to almost 1.3 times the pressure in the first stage. The pressures in the third and the following stages are notably diminished. The curve in Fig. 22, obtained between the air chamber and the origin, shows a slightly reduced maximum pressure (14.6 atmospheres); and the stages of the curve become rounded and rapidly lower.

Quite different results were obtained when the size of the air chamber was materially increased. Fig. 23 shows a curve obtained in house I (between air chamber and gate) with the use of an air chamber of 548 cubic inches, or 9 times that used in the experiments just described. The velocity of flow was 1.8 feet. This curve is very much like those usually obtained without the use of air chambers; the pressure wave is reflected from a large air cham-

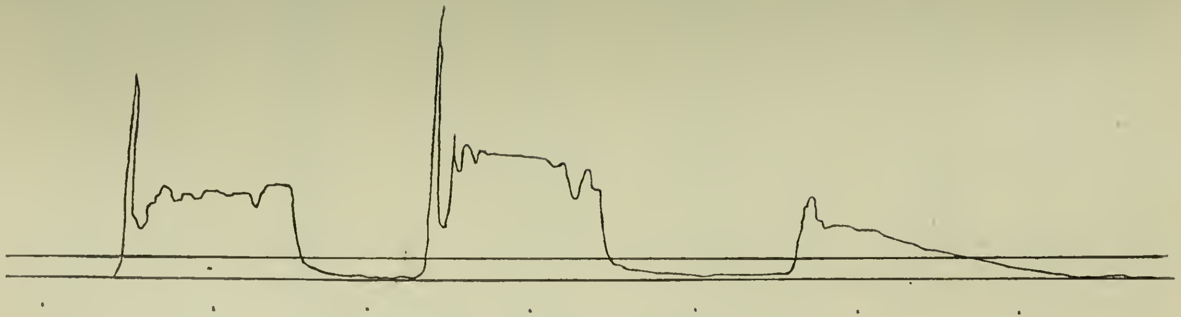

Fig. 21. Diagram taken between the Gate and the Air Chamber.

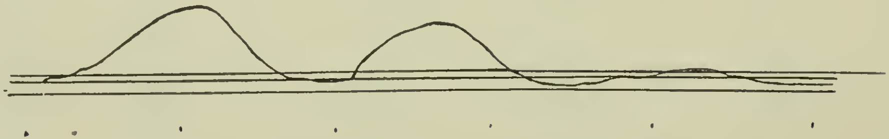

Fig. 22. Diagram taken between the Air Chamber and the Origin.

Indicator Diagrams in the Case of a Small Air Chamber.

ber as from the origin. The pressure here is 7.1 atmospheres, which corresponds closely with the theoretical pressure, $P = 4\,v = 7.2$ atmospheres. The diagram recorded in this case between the air chamber and the origin is a straight line, coinciding with the straight line of the original hydrodynamic pressure, showing that an air chamber of this size does not allow a water hammer of the given intensity to pass through it.

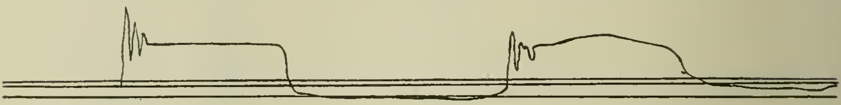

FIG. 23. INDICATOR DIAGRAM TAKEN BETWEEN THE GATE AND A LARGE AIR CHAMBER.

Explanation of Principles.

Suppose a water pipe, A B, on which an air chamber, C, is placed (see Fig. 24).* Upon sudden closure of the gate, B, the water near the gate is compressed† to the pressure $P = h.v$ atmospheres, and, after some moments, the pres-

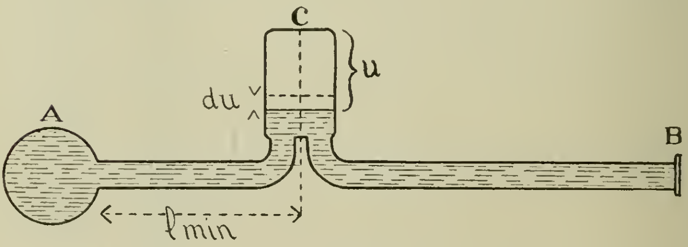

FIG. 24.

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* It is only for the sake of clearness that the 2 pipes are shown entering the air chamber separately. This does not affect the principle involved.

† See page 356.

sure wave, moving with velocity λ, will arrive at the air chamber, C. At that moment, the pressure at C, as well as in the pipe between the air chamber and the origin, is still the original hydrodynamic pressure, p_1. Therefore, the compressed water finds an outlet into the air chamber, which it enters with the original velocity v (which is now in the inverse direction).

Hence, the presence of the air chamber causes the pressure wave to be reflected not from the main, A, but from the air chamber, C.

We see also that the air chamber causes no reduction of the shock pressure in the section, B C, of the pipe between the gate and the air chamber. The experiments of Joukovsky with air chambers have even shown an increase of pressure in this section at the beginning of the second cycle, this increase (which in one case reached 50 per cent.; see Table XI, page 411, last column) being due to the compression of the air in the chamber and its subsequent reaction, which throws the water toward the gate, where a subnormal pressure already exists.

Let us now pass to the effect of the air chamber upon the section of the pipe, C A, between the air chamber and the origin. The water here continues to flow in the original direction, A C, and with the original velocity, v, until the pressure wave arrives at the air chamber, C. From this moment the pressure in the chamber increases because of the water coming into it from both sides (from B C and from A C). But the increase of pressure in the chamber, and the compression of the air there, gradually stop the entrance of water into it, and *affect the part, A C (and that part only), in the same way as if the flow from the pipe, A C, were stopped by a slow closure of a gate placed on the pipe at C.*

Conclusion: It has already been explained that a slow closure of a gate, lasting longer than a double run of the pressure wave through the length of the pipe,* prevents the exertion of the maximum shock pressure.

It is evident that the flowing of water into the air chamber will last longer with a large than with a small volume of air; consequently, the stoppage of the column of water, A C, will be slower, and the shock pressure less, in the first case. Therefore, the air chamber must be of large dimensions. As already stated, small air chambers do not accomplish their purpose, being even harmful, increasing the additional pressure in the section, B C, between the gate and the air chamber.

We see, then, that the air chamber reflects the pressure wave, allowing to pass through it only that part of the shock pressure which corresponds to the size of the chamber; in other words, *only that pressure is exerted in the pipe, A C (between the air chamber and the origin), to which the air in the chamber has been raised.*

Formula for the Required Volume of Air Chamber.

The formula for the determination of the size of the air chamber, which will allow to pass through it only a shock pressure of given intensity, is deduced as follows:

Let u = variable volume of air in the air chamber.
v = original velocity of flow in the pipe.
d = diameter of the pipe.
$P = h\,v$ = maximum additional shock pressure due to the checking of the velocity, v.
P_a = maximum additional shock pressure which will appear in the air chamber and will be carried along the pipe beyond the air chamber.
P_u = variable additional pressure in the air chamber, corresponding to the variable volume, u.

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* See page 396.

k = a constant numerical value, characterizing the thermodynamic properties of the gas contained in the chamber. (In the case of air, $k = 1.4$).

t = duration of a round trip of the pressure wave (with velocity λ) from the air chamber to the nearest end (distance $= l_{min}$) of the pipe (whether the gate or the origin) and back;

$$t = \frac{2\, l_{min}}{\lambda}$$

p_0 = the original hydrostatic pressure in the air chamber.

u_0 = volume of air in the air chamber corresponding to the original hydrostatic pressure, p_0.

p_1 = original hydrodynamic pressure in the air chamber.

u_1 = volume of air in the air chamber corresponding to the original hydrodynamic pressure, p_1.

At the moment when the pressure wave reaches the air chamber (which still has the original hydrodynamic pressure, p_1), the water will enter the chamber from *both* sides with the *original velocity,* v. It is evident that the volume of water, flowing into the chamber, must be equal to the reduction of the volume of air due to its compression. This compression and the resulting increase of pressure in the chamber gradually reduce the velocity of the water flowing into it. When the additional pressure in the chamber becomes $= P_a$, that is to say, when the total pressure there is $= p_1 + P_a$, the flow of water into the chamber will cease.

From the general theory of water hammer, we know that P stands in direct proportion to the reduction of velocity of flow in the pipe ($P = v.h$).* Consequently, if some additional pressure, P_u, has appeared in the air chamber, we know that the velocity of flow in the pipe has been reduced by $\frac{P_u}{h}$ and is equal to $\left(v - \frac{P_u}{h}\right)$. This is the velocity with which water will flow from both sides into the air chamber when the additional pressure there is P_u.

We thus obtain the equation: The reduction of air volume in the chamber ($- d u$) during each small interval of time ($d t$) is equal to the volume of water, which, during this interval of time ($d t$), has entered the air chamber from both sides.

The velocity of the entering water is, as has been already shown, $\left(v - \frac{P_u}{h}\right)$.

The area of the cross-section of the pipe is $\frac{\pi d^2}{4}$.

Hence, in a unit of time, each of the pipes will bring into the air chamber $\frac{\pi d^2}{4}\left(v - \frac{P_u}{h}\right)$ cubic units of water.

During the interval, $d t$, each pipe will bring in

$$\frac{\pi d^2}{4}\left(v - \frac{P_u}{h}\right) dt$$

of water. Two pipes will let in twice this amount of water, and this amount will be equal to the reduction of volume of air in the chamber. Consequently,

$$-du = \frac{\pi d^2}{2}\left(v - \frac{P_u}{h}\right) dt.$$

This is the differential equation of air compression in the chamber by the water entering it.

The flowing of water into the air chamber and the compression of air therein will continue until the state of compression of water in the air chamber (in the form of a wave, moving with velocity λ) arrives at the end of the pipe nearest to the chamber, and will return thence to the air chamber with a lowered pressure. In other words, it will continue until the water begins to flow from the air chamber, which will result in a lowering of pressure. In order to find the amount of additional pressure, which will originate in the air chamber and will be transmitted along the pipe beyond the air chamber, we must *integrate* the above equation for the time, t.

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* See page 369.

The process of the compression of air in the chamber being rapid, we take it to be *adiabatic,* which is expressed by the physical law

$$u^k . p = \text{constant.}$$

Beginning with the equation on page 404

$$-du = \frac{\pi d^2}{2} \cdot \left(v - \frac{P_u}{h}\right) dt \qquad (1)$$

and, substituting $v = \frac{P}{h}$, (according to the equation $P = v\ h$) we have

$$-du = \frac{\pi d^2}{2} \left(\frac{P - P_u}{h}\right) \cdot dt \qquad (1')$$

From the equation of the adiabatic compression we have:

$$u_1^k p_1 = u^k (p_1 + P_u) = \text{Constant} \qquad (2)$$

$$u^k = \frac{u_1^k p_1}{p_1 + P_u} \qquad (2')$$

Differentiating this, we obtain:

$$k u^{k-1} du = \frac{-u_1^k p_1\, d P_u}{(p_1 + P_u)^2}$$

consequently

$$du = -\frac{u_1^k p_1 \, dP_u}{k u^{k-1}(p_1 + P_u)^2} \qquad (3)$$

From equation (2′) we see that

$$u^{k-1} = \frac{u_1^k p_1}{u(p_1 + P_u)} \;;$$

and that

$$u = \sqrt[k]{\frac{u_1^k p_1}{p_1 + P_u}} \;;$$

consequently

$$u^{k-1} = \frac{u_1^k p_1}{\sqrt[k]{\frac{u_1^k p_1}{p_1 + P_u}} \cdot (p_1 + P_u)} \;.$$

Substituting for u^{k-1}, in equation (3), its value, as just given, we find that

$$du = -\frac{1}{k} \cdot \frac{u_1 p_1^{\frac{1}{k}} \, dP_u}{(p_1 + P_u)^{\frac{k+1}{k}}} \qquad (4)$$

Substituting, for d u, in equation (1), the expression (4), we obtain:

$$\frac{1}{k} \cdot \frac{u_1 p_1^{\frac{1}{k}} \, dP_u}{(p_1 + P_u)^{\frac{k+1}{k}}} = \frac{\pi d^2}{2}\left(\frac{P - P_u}{h}\right) dt \;;$$

or

$$k \cdot \frac{\pi d^2}{2} \cdot \frac{dt}{p_1^{\frac{1}{k}} h} = u_1 \frac{dP_u}{(p_1 + P_u)^{\frac{k+1}{k}}(P - P_u)}$$

For convenience, let

$$z = \frac{p_1 + P_u}{p_1 + P} = \frac{\textit{pressure in air chamber}}{\textit{total max. pres. in pres. wave.}} \qquad (5)$$

Then

$$P_u = z(p_1+P) - p_1 \; ; \quad dP_u = (p_1+P)\,dz .$$

Substituting h by $\frac{P}{v}$ and using the adopted designations, we write:

$$\frac{k\pi d^2}{2}\cdot\frac{v\,dt}{p_1^{\frac{1}{k}}P} = u_1\frac{(p_1+P)\,dz}{(p_1+P_u)^{\frac{k+1}{k}}\left[P-z\,(p_1+P)+p_1\right]},$$

$$\frac{k\pi d^2}{2}\cdot\frac{p_1(p_1+P)^{\frac{k+1}{k}}}{p_1^{1+\frac{1}{k}}P}\,v\,dt =$$

$$= u_1\frac{dz}{\left(\frac{p_1+P_u}{p_1+P}\right)^{\frac{k+1}{k}}\;\frac{(p_1+P)(1-z)}{p_1+P}};$$

$$\frac{k\pi d^2}{2}\left(\frac{p_1+P}{p_1}\right)^{\frac{k+1}{k}}\frac{p_1}{P}\,v\,dt = u_1\,\frac{dz}{z^{\frac{k+1}{k}}(1-z)} \qquad (6)$$

Let us now integrate this equation for the time, t, during which the air in the air chamber is compressed and the additional pressure, P_u, increased from 0 to P_a. From our designation for z, it follows that the corresponding limits of the integration will be

$$z_0 = \frac{p_1}{p_1+P} \quad \text{and} \quad z_t = \frac{p_1+P_a}{p_1+P}.$$

The integration gives us:

$$\frac{k\pi d^2}{2}\left(\frac{p_1+P}{p_1}\right)^{\frac{k+1}{k}}\frac{p_1}{P}\,v\,t = u_1\int_{z_0}^{z_t}\frac{dz}{z^{\frac{k+1}{k}}(1-z)} . \qquad (7)$$

For brevity, let

$$\psi(z) = \int_{z_0}^{z_t} \frac{dz}{z^{\frac{k+1}{k}}(1-z)} \qquad (8)$$

For convenience, we will express u_1 in terms of the volume of the air chamber, u_0, corresponding to the static pressure, p_0.

According to the law of Mariotte,

$$u_1 = \frac{p_0 u_0}{p_1}$$

Substituting the expressions given, we obtain from (7):

$$u_0 = \frac{k \pi d^2}{2 \psi(z)} \left(\frac{p_1 + P}{p_1} \right)^{\frac{k+1}{k}} \frac{p_1^2}{P p_0} \, vt \qquad (9)$$

This is the exact analytical general formula showing the relation between the volume of the air chamber, u_0, and the intensity of additional shock pressure, P_a*, which the air chamber will allow to pass through it, and which is transmitted through the pipe beyond the chamber.

This formula, owing to the complexity of the function $\psi(z)$, is inconvenient for practical use. But for the special case mentioned below it is possible to obtain, from this general and exact formula, a convenient and sufficiently approximate one. When the additional shock pressure, P_a, which is allowed to pass through the air chamber, is small,† the difference between the limits of integration

$$z_0 = \frac{p_1}{p_1 + P} \quad \text{and} \quad z_t = \frac{p_1 + P_a}{p_1 + P}$$

is also small, and we may write, approximately:

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* P is included in the designation $\psi(z)$, in z_t.

† For instance, 0.7 atmosphere, as in Table XI, page 411.

$$\psi(z) = \int_{z_0}^{z_t} \frac{dz}{z^{\frac{k+1}{k}}(1-z)} = \frac{z_t - z_0}{z_0^{\frac{k+1}{k}}(1-z_0)};$$

or

$$\psi(z) = \frac{\dfrac{p_1 + P_a}{p_1 + P} - \dfrac{p_1}{p_1 + P}}{\left(\dfrac{p_1}{p_1 + P}\right)^{\frac{k+1}{k}}\left(1 - \dfrac{p_1}{p_1 + P}\right)}.$$

Simplifying, we have

$$\psi(z) = \left(\frac{p_1 + P}{p_1}\right)^{\frac{k+1}{k}} \frac{P_a}{P} \qquad (10)$$

Substituting this approximate value of $\psi(z)$ in the formula (9), we obtain:

$$u_0 = \frac{k\pi d^2}{2} v t \frac{p_1^2}{p_0 P_a} \qquad (11)$$

Here u_0 is the minimum volume which the air chamber must have, in order that the shock pressure, P_a, in that portion of the pipe lying between it and the origin, shall not exceed the allowed intensity.

But this formula (11) is sufficiently approximate only when the allowed P_a is small; that is to say, when the volume of the air chamber is great. With small air chambers, great shock pressures pass through them, and the exact formula (9) must be used.

For the direct use of formula (9), tables of the function ψ should be calculated; but Joukovsky used this formula for the determination of two limits, between which the true value of ψ is included.

According to formula (5), $z < 1$.

Therefore, by formula (8), where, as a matter of fact, $k = 1.4$;

$$\text{if } k = 1, \quad \psi_1 > \psi;$$
$$\text{if } k = 2, \quad \psi_2 < \psi.$$

The corresponding actual value of ψ lies between ψ_1 and ψ_2, or between

$$\left.\begin{aligned} \psi_1 &= \frac{1}{z_0} - \frac{1}{z_t} + \log\left(\frac{1}{z_0} - 1\right) - \log\left(\frac{1}{z_t} - 1\right); \\ \psi_2 &= 2\left(\frac{1}{y_0} - \frac{1}{y_t}\right) + \log\left[\frac{\frac{1}{y_0} - 1}{\frac{1}{y_0} + 1}\right] - \log\left[\frac{\frac{1}{y_t} - 1}{\frac{1}{y_t} + 1}\right]; \end{aligned}\right\} \quad (12)$$

Here log = Napierian logarithm, and $y = \sqrt{z}$. Thus:

$$y_0 = \sqrt{z_0}, \quad \text{and } y_t = \sqrt{z_t}.$$

The volumes of the air chambers, in the first four experiments given in the table, were calculated by this method.

It must be observed that an air chamber, placed very close to the gate, and of half the volume required by the formula, will restrict the maximum shock pressure to the permissible pressure, P_a. This follows from what has been said above,* the water in this case entering the air chamber from one side only.

The following table gives the full data of the pressure curves obtained on October 9, 1897, and shows (in columns 4 and 5, and in columns 9 and 10) the extent to which the experiments sustained the formula:

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* See page 404.

TABLE XI.

INFLUENCE OF AIR CHAMBERS ON WATER HAMMER. RECORD OF EXPERIMENTS ON THE 2-INCH PIPE, OCTOBER 9, 1897.

No. of Experiment.	Original Velocity of Flow, v, in Feet per Second.	Duration, t, of a Round Trip of the Wave from the Air Chamber to the Nearest End of the Pipe and Back, in Seconds.	Maximum Shock Pressure, P, at House I, between the Gate and the Air Chamber.		Hydrostatic Pressure, p_0, in the Air Chamber before the Experiment.	Hydrodynamic Pressure, p_1, in the Air Chamber before Water Hammer.	Maximum Shock Pressure, P_a, in the Air Chamber.	Volume, u_0, of Air in Air Chamber in Cubic Inches. u_0		Ratio of Pressures, at House I, in the 2d and 1st Cycles.
	v	t	Observed.	Calculated $P = 4 v$.	p_0	p_1	P_a	Observed.	By the Formula.	
1	2	3	4	5	6	7	8	9	10	11
1, 2, 3	4.4	0.50	17.3	17.6	5.4	2.7	14.6	60	55–69	1.3
4	3.7	0.50	14.8	14.8	5.3	2.5	13.4	40	41–66	1.5
5	3.9	0.50	15.7	15.6	5.4	3.1	0.7	548	523	1.1
6	1.8	0.50	7.1	7.2	5.4	4.6	0.7	548	532	1.1

The conclusions of Joukovsky are as follows:

"*Air chambers of adequate size protect that part of the water pipe between the air chamber and the origin. This adequate size is, in general, quite large.* If, for instance, in experiment No. 8, with the 6-inch pipe, Table IX, page 384, we should wish to reduce the water-hammer pressure from 29 atmospheres (as it was in that case) to 1 atmosphere, the formula,

$$u_o = \frac{k\pi d^2}{2} vt \frac{p_1^2}{p_o P_a}$$

(assuming $p_o = p_1 = 5.4$ atmospheres) would give 5.68 cubic feet as the necessary volume.

But the chief practical inconvenience of using air chambers is that *it is difficult to keep the adequate quantity of air in them.* The observations of October 9, 1897, have shown that the volume of air in the chambers, which at the beginning of the experiments was 60 and 40 cubic inches, was, at the end of the experiments, reduced to 50 and 37 cubic inches, respectively.

This circumstance necessitates the use of special machinery for keeping the air chambers supplied with air. *Hence the use of safety valves is preferable.**

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* The practical experience with the Moscow waterworks is in accord with the views of Professor Joukovsky. N. P. Simin, chief engineer of these waterworks, has recently written as follows: "It is almost impossible to protect the pipe system from water hammer by the use of air chambers, because the air very quickly disappears from these devices, probably being entrained in the water and perhaps passing through the cast iron of the air chamber. The only places where it is possible to use air chambers successfully are the pumping plants, but here it is necessary to keep the air chambers artificially filled with air."

5. *Efficiency of Safety Valves.*

Experiments with safety valves were made with the 2-inch pipe which had been used for the experiments with the air chambers just described. Spring safety valves were located in about the same places where the air chambers had been set before. About a quarter of a second after the dropping of the weight (which closed the gate) the pressure wave arrived at the safety valve, and, opening it, threw out water from it in shape of a fountain. This lasted about a half second, or until the wave of reduced pressure reached the safety valve, when the valve closed itself. This opening and closing of the safety valve was repeated periodically several times because of the successive reflections of the pressure wave from the gate and from the open safety valve,* until the pressure was reduced to such an extent that it ceased to open the safety valve.

Diagrams of pressure were recorded in house I, near the gate, and in house III, beyond the safety valve. Samples of the diagrams obtained, corresponding to the velocity of flow, $v = 3.81$ feet, are given in Fig. 25. The first of these diagrams was obtained in house I. Its first rise shows a pressure of 15.3 atmospheres, which well corresponds with the theoretical $4\ v = 15.2$. The second of these diagrams was obtained in house III. Its first rise shows 3.1 atmospheres above the hydrostatic pressure, which accords with the elasticity of the spring of the safety valve. The table on page 415 gives the results of six observations, made October 9, 1897.

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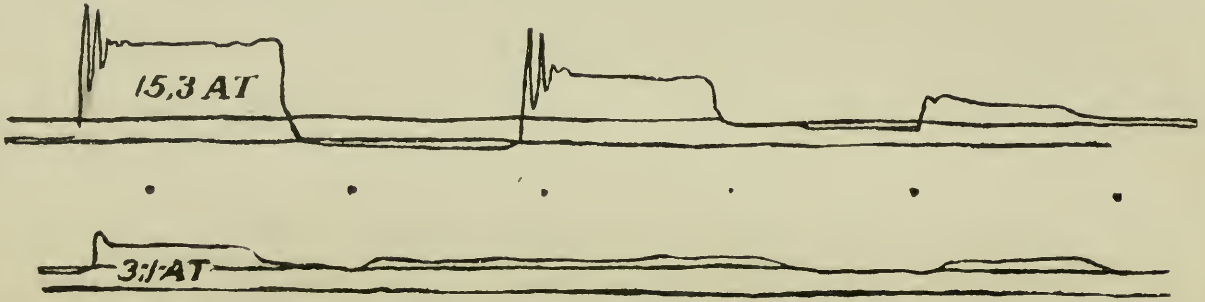
* For "reflected wave," see page 391.



$D = 2''$; $v = 3.81'$

Fig. 25. Indicator Diagrams in the Case of a Safety Valve.

TABLE XII.

INFLUENCE OF SAFETY VALVES ON THE WATER HAMMER. RECORD OF EXPERIMENTS ON THE 2-INCH PIPE, OCTOBER 9, 1897.

No. of Experiment.	Velocity of Water, in Feet per Second, v.	Duration of Round Trip of the Wave from Safety Valve to the Gate, in Seconds.	P from Diagram in House I.	P by the Formula P = 4 v.	P from Diagram in House III.	Ratio between First and Second Rise, House I.
1	2	3	4	5	6	7
1	4.39	0.50	17.3	17.6	3.5	1.4
2	4 39	0.50	17.3	17.6	3.5	1.5
3	3.79	0.50	15.5	15.2	3.1	1.5
4	3.81	0.50	15.5	15.2	3.6	1.5
5	3.81	0.50	15.3	15.2	3.1	1.5
6	2 58	0.49	10.3	10.3	3.5	1.4

Beyond the safety valve (house III, column 6) the shock pressure is practically constant, depending upon and limited by the tension of the spring.

Column 7, which gives the relation of the height of the first to the height of the second rise of the curve obtained in house I, shows a rapid extinction of the vibration of the hammer pressure in the pipe. These experiments show that *the safety valve allows to pass through it only such a hammer pressure as corresponds to the elasticity of the spring of the safety valve,* and thus demonstrates the usefulness of the safety valve.

Mr. N. P. Simin writes as follows:

"About 18 years ago, when the waterworks in the city of Samara were built, I was much concerned with the question of protecting its pipe system from water hammer. These waterworks were designed for direct pressure fire service from hydrants under a pressure of 10 atmospheres. This was the first fire protection water supply in Russia, and many fears were expressed respecting the durability of its pipes. Some altogether refused to believe that such a water supply could work satisfactorily, and I was therefore especially careful in taking measures against water hammer. I decided to use safety valves. The Samara pipe system, which then had a length of 25 miles, was equipped with 16 safety valves of 2 inches diameter. This measure proved to be satisfactory, notwithstanding the frequent use of the fire hydrants of the waterworks in cases of fires and still more often in cases of false fire alarms. During the 16 years of the existence of the Samara waterworks there has not been recorded a single case of injury to the pipes or their joints. This can be explained only by the use of the safety valves."

As a result of the experiments of Joukovsky at the Alexeievskaia pumping plant, an ordinance was passed by the Imperial Water Commission of Moscow, placing safety valves at the beginnings of all service pipes of the waterworks. This ordinance is still in force, a specially devised type of $1\frac{1}{4}$-inch safety valve being used. The total number of safety valves at the Moscow waterworks is now over 1500.

6. *Water Hammer as a Means for Locating Accumulations of Air in Mains.*

Fig. 26 shows a pressure curve obtained in house I, on the 2-inch pipe. Curves of a similar shape were obtained in a series of experiments performed September 1, 1897. The aim of these experiments was to test the formula

$$P = \frac{v \lambda \gamma}{g}$$

where

P = additional pressure due to water hammer, in pounds per square inch.

v = velocity checked.

λ = speed of progagation of pressure wave.
γ = density of water.
g = acceleration of gravity.

The diagrams obtained (Fig. 26) were at first regarded as failures, owing to the sharp depressions shown at a, b and c; but these depressions attracted the attention of Professor Joukovsky by the regularity with which they appeared at the same point on each of the diagrams; and, upon inspection of the system of pipes upon which the experiments were performed, it was found that, at distances of 1357 feet, 2066 feet and 2351 feet, respectively, from the gate (where the manometer tubes had been attached to the 2-inch pipe), air pockets had formed in the pipe line.

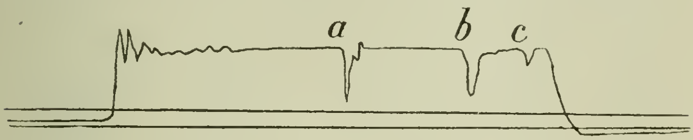


FIG. 26. INDICATOR DIAGRAM IN THE CASE OF AIR POCKETS.

The distances on the diagram from the first increase of pressure to each of the 3 depressions, a, b and c, Fig. 26, expressed in time units, were found to be in all cases double the distances of the air pockets, respectively, from the point where the diagram was taken. This enables us readily to locate an air pocket by means of the diagram.

The width of the depression, indicated in time units, is roughly proportional to the volume of the air pocket.

When an air pocket is located nearer to the gate than to the origin, a second depression, due to the reflection, by the gate, of the effect of the same air pocket, appears in the pipe at a distance, from the beginning of the diagram, double that of the first depression.

The table on page 418 gives the results of 7 experiments made September 1, 1897:

TABLE XIII.

DETERMINATION OF LOCATION OF AIR POCKETS. RECORD OF EXPERIMENTS ON THE 2-INCH PIPE, SEPTEMBER 1, 1897.

No. of Experiment.	Velocity, in Feet per Second, v	Distances on the Diagram, in Seconds, of the Depressions, from the Point Corresponding to the First Increase of Pressure.		
		A	B	C
1	2	3	4	5
1	4.42	0.64	1.00	1.15
2	4.42	0.65	1.00	1.13
3	4.37	0.64	1.00	1.14
4	4.34	0.65	1.00	1.14
5	3.29	0.64	1.00	1.14
6	3.17	0.63	0.96	1.13
7	3.18	0.65	0.99	1.15
Average	. . .	0.64	0.99	1.14
Corresponding distances of air pocket, calculated (λ = 4200 feet per second) . . Feet		1344	2079	2394
Actual . . . . . Feet		1357	2066	2351
Discrepancy . . Feet		13	13	43

A very slight water hammer is sufficient for this purpose. Hence the use of this method need involve no risk to the mains.

7. *Water Hammer as a Means of Locating Leaks.*

A number of small holes were made in the 2-inch pipe, and provided with means for closing them. With one of these holes opened, the gate was opened and the flow measured. The gate was then suddenly closed, and pressure curves were obtained in the 3 houses (although but one curve from house I really sufficed for location of the hole).

Fig. 27 represents such a curve obtained with a velocity of 4.2 feet per second and with a hole open 949 feet from the gate. The depression at *a* marks the location of the hole.

The diagram gives 0.44 second* as the time interval between the first rise of the curve and the depression, a. Taking $\lambda = 4200$ feet per second, we have, for the calculated distance of the hole from the gate, $\frac{0.44 \lambda}{2} = \frac{0.44 \times 4200}{2} = 924$ feet. This is only 25 feet less than the actual distance, and it will be seen that this method furnishes a convenient means for the location of leaks. Here, as in the location of air pockets, a very slight water hammer suffices for the purpose.

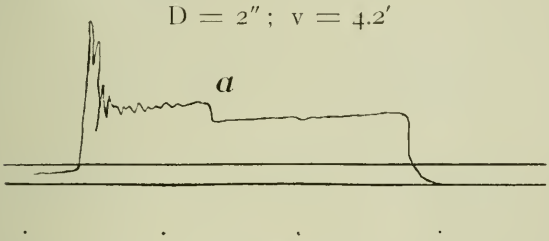


FIG. 27. INDICATOR DIAGRAM IN THE CASE OF A LEAK.

Table XIV, page 420, gives the results of the observations made September 25, 1897, upon 2-inch pipe line 2494 feet long.

Joukovsky assumed in his calculations $\lambda = 4200$, but he notes that, according to the duration of the double run of the wave through the length of the pipe, the quantity $\lambda = 4200$, the assumed value, was correct only at the beginning of the water hammer. Afterward (when the air had been disengaged from the water) λ increased to 4333 feet, making the calculated distance 1.03 times greater. Thus, instead of 924 feet, we have 952 feet, or 3 feet greater than the actual distance.

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* The points under the curve in Fig. 27 indicate half-second intervals.

TABLE XIV.

Determination of Location of Leaks. Record of Experiments on the 2-inch Pipe, September 25, 1897.

No. of Experiment.	No. of Hole.	Velocity, in Feet per Second. v	Duration of Round Trip of Wave Through the Whole Pipe, in Seconds.	Diagram I.			Diagram II.			Diagram III.		
				Duration of Round Trip,* in Seconds.	Distance, in *sagens*,† from Gate to Hole.		Duration of Round Trip,* in Seconds.	Distance, in *sagens*,† from Gate to Hole.		Duration of Round Trip,* in Seconds.	Distance, in *sagens*,† from Gate to Hole.	
					Calculated.	Actual.		Calculated.	Actual.		Calculated.	Actual.
1	2	3	4	5	6	7	8	9	10	11	12	13
1	3	3.92	1.18	0.20	60	56.5	. . . .	. . . .	. . . .	. . .	. . .	. . .
2	4 (a)	3.86	1.16	0.25	75	76.9	0.25	75	76.9	. . .	. . .	. . .
3	4 (a)	4.18	1.15	0.26	78	76.9	0.25	75	76.9	. . .	. . .	. . .
4	6	3.61	1.15	0.46	138	135.6	0.44	132	135.6	. . .	. . .	. . .
5	6	3.60	1.15	0.44	132	135.6	0.47	141	135.6	. . .	. . .	. . .
							Distance from House II.					
6	7 (a)	3.87	1.13	0.66	198	193.9	0.25	75	76.2	. . .	. . .	. . .
7	7 (a)	4.42	1.15	0.66	198	193.9	. . . .	. . . .	. . . .	. . .	. . .	. . .
8	8 (a)	3.87	1.14	0.86	258	250.6	0.46	138	133.13	Distance from House III.		
9	8 (a)	4.42	1.14	0.82	246	250.6	. . . .	. . . .	. . . .	0.064	19.2	20.2
10	10	4.13	1.15	1.02	306	315.0	0.62	186	197.9	0.270	8.10	80.9

*From gate to hole and back. †1 sagen = 7 feet.

V. SUMMARY AND CONCLUSIONS.

1. *The shock pressure is transmitted through the pipe with a constant velocity, which seems to be independent of the intensity of the shock. This velocity depends upon the elasticity of the material of the pipes and upon the ratio of the thickness of their walls to their diameter.* Ordinarily, in cast-iron pipes the ratio of thickness to diameter decreases somewhat with increase of the diameter; hence the velocity of the pressure wave is a little less, in pipes of large diameters, than in pipes of smaller diameters. *For pipes of diameters from 2 to 6 inches this velocity is about 4200 feet per second; for 24-inch pipes it is about 3290 feet per second.*

The speed of propagation of the pressure wave remains the same, whether the shock is caused by arresting the flow of a column of water moving in a pipe, or by suddenly changing the pressure in the column of water (flowing or standing) in any part and by any other means.

2. *The shock pressure is transmitted along the pipe with a constant intensity. The shock pressure is proportional to the destroyed velocity of flow and to the speed of propagation of the pressure wave. For ordinary cast-iron pipes, of diameters from 2 to 6 inches, the increase of pressure, for every foot per second of extinguished velocity of flow, is about 4 atmospheres, and, for a 24-inch pipe, about 3 atmospheres.*

3. The phenomenon of periodical vibration of the shock pressure is completely explained by the reflection of the pressure wave from the ends of the pipe, *i. e.*, from the gate and from the origin.

4. If the water column continues flowing, such flow exerts no noticeable influence upon the shock pressure. In a pipe from which water is flowing, the pressure wave is reflected from the open end of the pipe, in the same way as from a reservoir with constant pressure.

5. A dangerous increase of shock pressure occurs when the pressure wave passes from a pipe into another of smaller diameter with a dead end. In this case the shock pressure is doubled when the wave reaches the dead end. Where there are several branches, one from another, this doubling may take place several times and these doubled pressures accumulated, so that, under unfavorable conditions, the pressure may become very great.

6. The simplest method of protecting water pipes from water hammer is found in the use of slow-closing gates. The duration of closure should be proportional to the length of the pipe line. Air chambers, of adequate size, placed near the valves and gates, eliminate almost entirely the hydraulic shock, and do not allow the pressure wave to pass through them; but they must be very large, and it is difficult to keep them supplied with air. Safety valves allow to pass through them pressure waves of only such intensity as corresponds to the elasticity of the springs of the safety valves.

7. The diagram of the shock pressure enables us to determine the location and extent of air pockets. They serve also for the location of leaks, and generally for a study of the condition of the pipe line.

MR. RUDOLPH HERING (by letter): This paper, based on experiments in pipes of large diameters, conducted with a good knowledge of the subject and apparently with much care, is a valuable contribution to practical hydraulic science. It is, in fact, the best contribution we have on the subject of which it treats.

The pipes not only have a wide range from 2 inches to 24 inches in diameter, but also of lengths varying from 1,066 feet to 7,007 feet. The gauges for measuring pressures and speed of shock waves were apparently in duplicate, and serve to confirm each other. The graphical representations add much to a clear comprehension of the subject.

The general phenomena are well known. They are often discovered only through disaster. The necessity for slowly closing the gates, so as to prevent a water ram, particularly on long pipes, was also well known. But the relation between cause and effect has been determined much more definitely by Prof. Joukovsky than had been known before. It is interesting to note how, after a sudden closing of the gate, water "piles up" as it were, by compression which is caused by the momentum of the flowing water. The water is first compressed near the gate, and the compression rapidly continues in the water towards the origin traveling at the rate of about 4,000 feet a second. It would have been interesting to have learned also the amount and rate of inflow at the origin, so as to have verified the compressibility of water and possible expansion of the pipe. The reaction when the water expanded to its normal state and the wave returned to the gate, would also have given an interesting rate of outflow. The latter, through the momentum which it has obtained, causes a second "round trip," due to the elasticity of water, and therefore the pendulum-like pulsation which continues until friction brings about rest.

Of special value is Joukovsky's deduction of the law between speed of closure of the gate and increase of pressure caused thereby, and also the law between the volume of air required to neutralize by compression the additional pressure caused by the water ram.

PRIVATE FIRE SYSTEMS.

By L. N. Case.

Manager Water and Light Dept., Duluth, Minn.

The conditions of Duluth's water supply, and the fact of there being many business enterprises already, or on the point of being, equipped with private fire systems of various kinds and dimensions, rendered it necessary for the department early in my management, to arrive at some solution of the questions now being agitated as to what regulations should be generally adopted governing them and upon what basis a charge should be made for services rendered.

While it is not my purpose or desire to submit the results that we finally arrived at, as the *only* way, or even the *right* way, to control these systems, I do submit them as the result of our best judgment after much careful thought, and a way also, which is more conclusive, that has been for two years in harmonious and satisfactory operation.

The conditions spoken of are, that Duluth has been for years supplied by two independent companies, the central or main portion coming under my control in October, 1898, and the West Duluth branch in January of last year. Various and somewhat peculiar were the requirements and charges made by these companies, and apparently without any accord in their methods.

As you are no doubt aware, at the head of the lakes are established a large number of saw mills, lumber yards, elevators, ore docks and railroad property, besides large buildings; all of which are equipped, or being equipped, with different kinds of systems for the suppression of fires. Most of these are of what is known as the "wet" or "dry" sprinkler system, with storage tanks of various capacities; some are equipped with simply a pipe line with hydrants, and some with independent lines with hose connections on the different floors with hose attached ready for use.

It is required in the first place that a written application be made for each of these services, and that where such application does not state clearly that the system is entirely independent from their ordinary supply, they are required to meter the service.

This application also contains an agreement by the applicant to pay the rate established for the privilege accorded and for expense of inspection, running from $5 to $50 per annum, and to pay also for all consumption of water used or wasted from the system, other than for the actual suppression of fires, at the regular schedule of rates.

When the application is received and the permit granted, every opening and valve controlling the system, if found necessary, are sealed with the ordinary copper wire and lead disc attachment, which are inspected monthly or oftener if we have any reason for thinking they are being tampered with.

In addition to this, in order to discover if, and to what extent, water is running away through any cause, in underground or covered pipes, we require a bypass on the valve controlling the system, and on the bypass is installed a five-eighth (⅝) inch meter.

Once each month, or oftener, if necessary, the large valve is closed and a record made of the registration of the meter, if there is any.

If the meter indicates a consumption of water, one hour's registration is recorded, and a notice is served on the firm of the above conditions. Every five or ten days thereafter, a registration is taken and at the end of the month a bill is rendered of a continuous consumption indicated by readings above referred to.

In one of these systems, that of a saw mill, which consists of a pipe line and hydrants only, we found on inspection that the seal had been broken, and upon inquiry were told that it was done for the purpose of using water for boilers after blowing off. The firm claimed it was done without their knowledge or consent by a lessee of that portion of the mill, and that it would not occur again. In the course of the next three months this happened five different times, upon which we sent them a bill for $25, which, after many protests and attempts to evade, was paid. Since that happened, whenever they wish to use water from the hydrant they call up the office and a man is sent to operate the hydrant, the firm paying for the man's time and the quantity of water used, estimated under the valuable table provided the Association by Mr. Charles.

Now, as to the regular charge made: If the system consists of mains ramifying through grounds and buildings, the charge is invariably $50 per annum. If it is a building only, a charge is made upon the basis of the capacity of the system, including tank and pipe lines. With our schedule of rates, four times this quantity for an annual consumption is sufficient to reimburse the Department for all expenses.

It is to be remembered in this connection that the city pays the department a hydrant rental from the tax levy, so that the question of remunerating the department for its maintenance of conditions in its construction for the purpose of fire protection or for the consumption of water used for such purpose, does not arise.

I am not an advocate of the use of meters upon these services except upon very small systems, as with larger meters a considerable quantity of water can be used without registration. With one consumer, Merrill & Ring, a large mill and lumber firm, we maintained a charge of from three to eight feet consumption per hour, based upon tests made with the small meter, some considerable part of which quantity would not have been registered by a six inch meter, the size of main going into the premises.

Again, the installation of a meter is objected to strenuously by insurance companies and private parties, because, in the first place, of their expense, but more particularly because of their restriction of the flow of water, should the full capacity of the main be at any time required.

In conclusion, I wish to say that we have found this manner of treatment satisfactory to our customers and to the department, and under which all special services are paid for, the illegal use of water prevented, and no obnoxious or objectionable requirements or regulations to private parties or insurance companies are sought to be enforced.

WATER SERVICE AT THE BALTIMORE FIRE.

By Alfred M. Quick.

Water Engineer, Baltimore, Md.

When I was asked By President Campbell early in March to prepare for the annual convention of the American Water Works Association, a paper on the Baltimore fire, with special reference to the water service, I promptly agreed to do so, without giving the matter any particular consideration; for it seemed to me that in an occurrence of such unusual magnitude there must be some valuable lessons to be learned in relation to every subject involved. After carefully considering the matter and attempting to collect information in preparation for such a paper, I find that while most valuable lessons are to be learned from the fire in relation to the comparative merits of different styles of building construction, of various building materials, and of various appliances for fire protection in buildings, I am somewhat doubtful as to whether much of any value is to be learned in relation to the water service.

However, there are three points that occur to me, the experiences of this fire in regard to which might suggest something valuable, or at least interesting, to water works officials.

1. As to the adequacy of any water service to successfully cope with such an emergency.

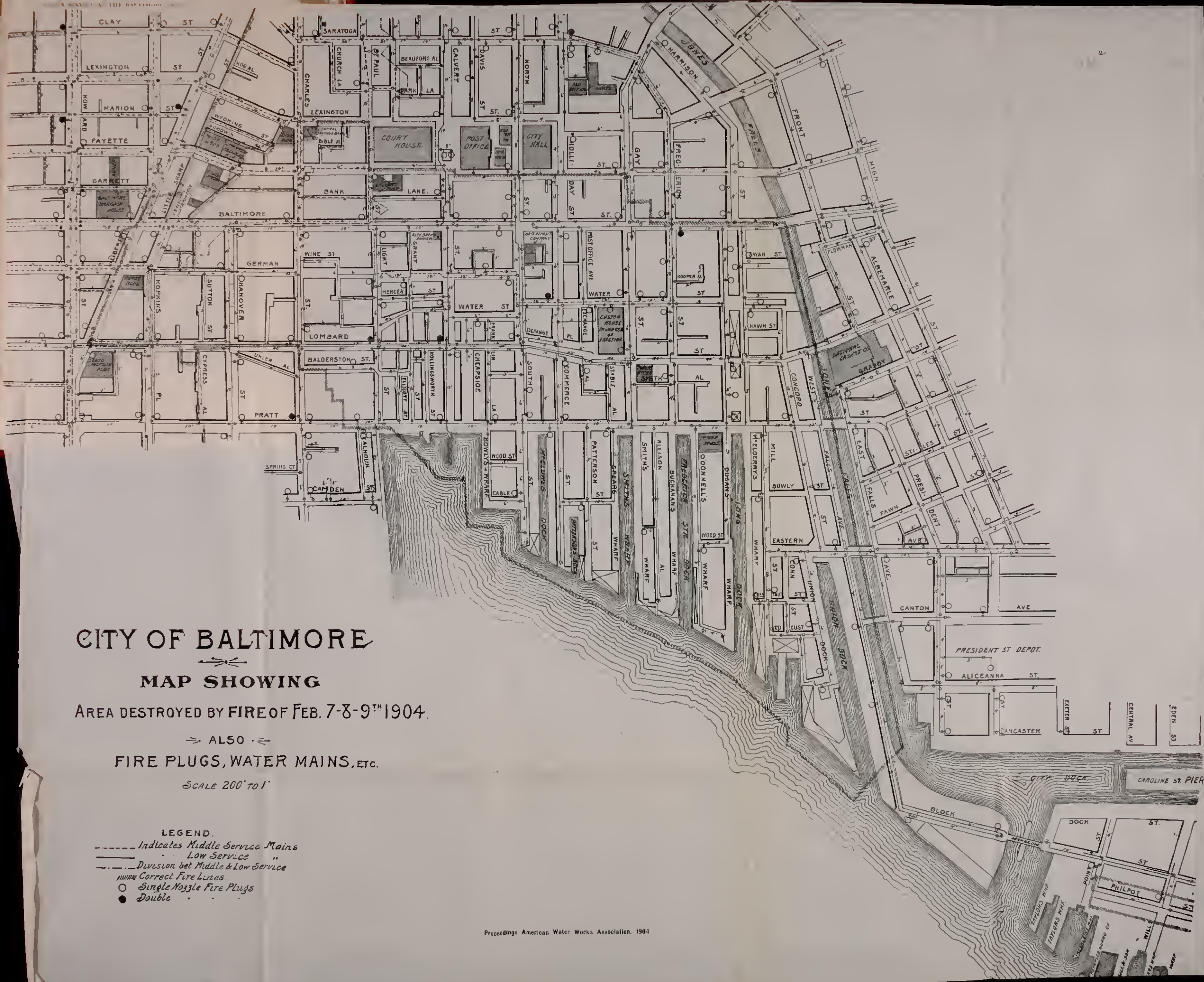
2. As to the effectiveness of private fire service fixtures in protecting property.

3. As to the possibility of the waste from broken water pipes in buildings destroyed by fire temporarily crippling the water service.

In order to make more intelligible what I have to say in regard to these points it will be necessary for me to first give a description of our water works system, of the origin and course of the fire, and of the water service during the fire, which I shall make as brief as possible. As a further aid to your comprehension of the matter, I have prepared the accompanying map showing the limits of the burned district, the water mains and fire hydrants, and the principal buildings.

WATER WORKS SYSTEM.

Baltimore's water supply is derived from two rivers draining to Chesapeake Bay, namely Jones Falls and the Gunpowder River. On the former the water from a shed of about forty square miles is impounded at a point about four miles above the city, and on the latter the water from a shed of about two hundred and sixty square miles is impounded at a point about seven miles from the city. From each of these two impounding reservoirs, tunnels convey the water to two clear water storage reservoirs in the city. The minimum average daily flow of the two sources of supply is about 120,000,000 gallons. The total capacity of the two impounding reservoirs is about 910,000,000 gallons. The delivering capacity of the two tunnels conveying the water to the city is about 200,000,000 gallons a day under the minimum head. The total available capacity of the four storage reservoirs is about 1,240,000,000 gallons. The average daily consumption is about 63,000,000 gallons. For distribution purposes the city is divided into four service areas, designated as low, middle, high, and upper, according to the elevation of the ground. The low service area, from tide water up to elevation 50, comprising most of the business and manufacturing districts, is supplied from the two Gunpowder storage reservoirs, having an elevation of 163 and a combined capacity of about 760,000,000 gallons, by gravity through two 40-inch main feeds. The middle service area, between elevations 50 and 100, comprising business and residence sections in about equal proportions, is sup-



CITY OF BALTIMORE

MAP SHOWING

AREA DESTROYED BY FIRE OF FEB. 7-8-9TH 1904.

ALSO

FIRE PLUGS, WATER MAINS, ETC.

Scale 200' to 1"

LEGEND.

- - - - - - *Indicates Middle Service Mains*
———— *" " Low Service "*
—.—._ *Division bet Middle & Low Service*
////// *Correct Fire Lines.*
○ *Single Nozzle Fire Plugs*
● *Double " " "*

Proceedings American Water Works Association, 1904

plied from the two Jones Falls storage reservoirs, having an elevation of 217 and a combined capacity of about 479,000,000 gallons, by gravity through one 40 and two 30-inch main feeds. The high service area, between elevations 100 and 250, entirely a residence section, is supplied by two pumping stations, taking suction from one of the low service storage reservoirs. The east side station, with two 10,000,000 gallon pumps, pumping through the distribution system to a 36,000,000 gallon reservoir at elevation 340. The west side station with two 17,500,000 gallon pumps, pumping through the distribution system to a 22,500,000 gallon reservoir at elevation 348. The upper service area, from elevation 250 to the highest elevation in the city (about 460), is supplied from a pumping station taking suction from one of the middle service reservoirs, with two 4,000,000 gallon pumps, pumping through the distribution system, one to an east side 200,000 gallon standpipe with a high water elevation of 450, and the other to a west side 330,000 gallon standpipe with a high water elevation of 550. There are also connections at both high service pumping stations to the middle service distribution system to sustain the middle service in dry seasons when the flow of Jones Falls is insufficient to keep up the supply.

About seven years ago our distribution system was extremely defective and inadequate. At that time a general plan of improvements was entered upon, involving the laying of miles of additional large mains all over the city, cutting out of service old small pipes that were choked with sediment and corrosion, connecting up dead ends and mains at street intersections, transferring hydrants from old small mains to large mains and increasing pressures generally all over the city by floating the upper, high and middle service down into the higher sections of the high, middle and low service areas. These improvements were planned to give a pressure of not less than forty pounds at any point, with the maximum domestic consumption drawing, and to allow at least 10,000 gallons a minute to be concentrated for fire service on any block in the closely built up section of the city, without a serious reduction of pressure. This work was practically completed last year and pressures taken all over the city indicate that the desired result has been accomplished so far as the supply for domestic service is concerned. The conflagration of February 7th and 8th gave the first opportunity since the improvements were begun to demonstrate whether the desired result in relation to fire service has been accomplished. The manner in which the system met the extraordinary demand upon it on that occasion will be shown later on in this paper.

With the improvements made in the last few years the distribution system in the burned district was in fairly good shape, though not an ideal arrangement. By referring to the map it will be seen that the extreme northwestern end of the district is in the middle service area, with ten-inch mains in nearly all of the main streets and these supplied from a forty-inch main running directly from the largest middle service reservoir to a point on Lombard street about three or four blocks west of the burned district. The rest of the district is in the low service area, with a forty-inch main running through its very center from east to west, feeding directly from the two large low service reservoirs. In that section are also ten-inch mains in Pratt and Lombard streets, a double line of ten-inch in Baltimore street, and ten-inch mains also in a number of the north and south streets, all interconnected. Also in that section is a twelve-inch middle service special fire line, making a loop through its center, running down Saint Paul street, to Light, to German, to South, to Water, to Frederick, and up Frederick street.

In the whole of the burned district are about one hundred and thirty fire hydrants, including five with two steamer nozzles, making about fourteen to each mile of main street in the district. There are eleven hydrants within two hundred feet of the location of the Hurst building where the fire started, and twenty-two within four hundred feet of the building.

THE ORIGIN AND COURSE OF THE FIRE.

The fire started about 10.45 Sunday forenoon, February 7th, in the Hurst building, a large six-story wholesale drygoods house at the southwest corner of Hopkins place and German street, probably from a lighted match carelessly dropped through a broken sidewalk light. Shortly after the first fire apparatus arrived an explosion of smoke in the building caused the fire to spread in all directions, even against the wind, which at that time was blowing from the southwest with considerable velocity. From the start until about 11 o'clock Sunday night, the fire spread principally in the direction of the wind, that is, to the northeast. At about 11 o'clock the wind changed to almost due west, and this fact, together with the efforts of the firemen, with the assistance of one really fire-proof building, some blank walls and two or three buildings equipped with private fire services or underwriter fire shutters, kept the fire from extending any further north than Lexington street. The wind holding from the west all early Monday morning and blowing strongly, drove the fire east to Jones' Falls. Towards noon on Monday the wind had veered to the northwest, blowing with still greater velocity, and the fire rapidly ate its way to the harbor, until it practically burned itself out; the firemen, aided by the natural barrier of Jones' Falls, being able to prevent its spreading any further to the east. By half-past four Monday afternoon, all danger of the fire spreading further in any direction was past.

WATER SERVICE DURING THE FIRE.

The fire started in the middle service area, where the normal pressure is from 55 to 65 pounds. About three hours after the fire started, as soon as it was evident that it had developed into a conflagration, we opened the connection to the middle service distribution system at one of our high service pumping stations, to which I have referred, and by that means increased the pressure in the middle service section of the burned district to 70 or 80 pounds. After the fire had burned out of the middle service district into the low service we opened a twelve-inch division stop between the two services, and at intervals thereafter we opened another twelve-inch and a twenty-inch division stop, at the same time keeping open the connection to the middle service at the pumping station, so as to sustain the pressure in that service. The normal pressure in the low service section of the burned district is from 40 to 55 pounds. The opening of these division stops from the middle service did not increase that pressure because by that time the draught for fire service was at the maximum, and the waste through broken service pipes in the burned buildings had become very great; but it did serve to hold the pressure up to the normal all over the low service district where fire engines were stationed. As the fire progressed employees of the water department went to all fire engines in service at fire hydrants to note the pressure and see if they were getting enough water. At no point was there any complaint of slack supply. If there had been we were prepared to open the middle service to the low at many other points, and, if necessary, to run either one or both of our reserve 10,000,000 and 17,500,000 gallon pumps at the high service stations directly into the middle service system.

We have Venturi meters on all of the five large mains leading from the middle and low service reservoirs to the distribution system. Regular weekly readings are taken from these meters every Saturday afternoon. Consequently we know exactly what the excess of consumption was for the week of the fire. It was, in round figures, 170,000,000 gallons. As we only put on the recording sheets when we wish to secure some special information, unfortunately these sheets were on only two or three of the Venturi meters at the time of the fire, and consequently we are unable to tell exactly what the maximum daily or hourly rate of excess consumption was at that time. However, from such Venturi meter record sheets as we have for that week and from estimates made as to the amount of water used in fighting the fire, we are able to approximate the maximum daily draught on the system due to the fire. This maximum draught, of course, came in the two days of the fire. We estimate that for those two days the total consumption of water in the city was about 230,000,000 gallons. With this largely increased consumption and with the outlet gates from our impounding reservoirs remaining as fixed to deliver only the ordinary domestic consumption, our storage reservoirs in the city, which have from twenty to twenty-five feet available depth, were drawn down only by from two to two and one-half feet. Even this slight reduction of head could have been prevented, if we had deemed it necessary, by simply opening wider the gates at the impounding reservoirs.

Now having given you this description of our water supply system and of the water service during the fire, which I hope I have made fairly intelligible, you are in a position to draw your own conclusions as to the adequacy of the system in meeting the extraordinary demands made upon it. It seems to me that there can be only the conclusion that it was entirely adequate for a fire-engine service. As, however, with an adequate water supply for a fire-engine service, the fire was not stopped until it had practically burned itself out at the water's edge, we are up to the question as to ——.

I.—THE ADEQUACY OF ANY WATER SERVICE TO SUCCESSFULLY COPE WITH SUCH AN EMERGENCY.

In contemplating this failure to stop the fire with a water service adequate for the method employed to fight it, certain questions will naturally suggest themselves, such as:—

Was there a sufficiency of fire apparatus? During the first few hours of the fire, before any outside fire companies arrived, only our own Fire Department force and apparatus were available for work. Practically the entire force and equipment were on duty, either in the burned district or in taking care of the numerous small fires started in other sections of the city by sparks from the main fire. There are in our Fire Department 438 men, 25 fire-engines, one fire-boat, a water-tower, 11 hook and ladder trucks, some of which have hose and chemical tanks, and 3 chemical wagons. The 25 fire-engines have the following capacities: 8 of 1,000 gallons a minute, 2 of 900, 4 of 750, 4 of 700, 1 of 650, 5 of 600, and 1 of 500. The combined capacity of these engines is about 19,000 gallons a minute. As the hook and ladder and chemical companies took care of all fires in outlying districts, all of the fire-engine companies were available for fighting the main fire. There were, therefore, about 280 men, including district chiefs, and 25 fire-engines, with a combined capacity of 19,000 gallons a minute, fighting the main fire during the first few hours when it had a maximum front of not over three blocks. These engines, of course, were not all pumping continuously, as they had to shift about as the fire progressed; nor were they at all times supplying the same number of hose lines. It is estimated by the Fire Department that the average conditions amounted to about two continuous fire streams to each engine, which would make 50 fire streams in constant service. It would seem as if this force and service would have been sufficient, under ordinary conditions, to have brought under control a fire with no greater extent of front than this one had before the arrival of outside aid.

In about three hours after the fire started the first outside fire company was in service, and from that time on other outside companies arrived and got into service very rapidly. By the time the fire was at its height with a maximum front of not over five blocks, the fire fighting force and equipment was augmented by 793 men, 32 fire-engines, four hose companies, and one hook and ladder truck, from outside cities and towns. The combined capacity of these fire-engines was about 27,000 gallons a minute, and under the average conditions of their service they gave the equivalent of about 50 continuous fire streams. As soon as the fire approached the wharves our fire-boat and the fire-pump on our Police-boat were also brought into service with a total capacity of about 5,000 gallons a minute.

It would seem, therefore, that a force of 1,073 men, with 57 fire-engines and 2 fire-boats, having a total capacity of over 50,000 gallons a minute keeping in continuous service over 100 fire streams, would have been sufficient, under ordinary conditions, to have brought under control a fire with a front of not over five blocks at its worst, before it could burn itself out at the water's edge.

Another question which suggests itself is: Were the firemen efficient and under intelligent supervision? As to the efficiency of the firemen and apparatus there can be no question. Baltimore's Fire Department has a well deserved reputation throughout the country for fearlessness and intelligent and effective fire fighting. All of its equipment is first-class in every particular and is kept in perfect condition. Anybody who is at all familiar with the subject knows of the records made by the firemen of New York, Philadelphia and Washington for brilliant, daring and effective work. Certainly no one who witnessed the work of the companies from these cities at the Baltimore fire could question for a moment their efficiency. The same is true of the firemen and apparatus from Wilmington, York and other places that so promptly and generously came to our aid on that occasion. As to the management of the men and apparatus there can also be no question. Although our veteran chief was disabled shortly after the fire began, there were in command at various points six experienced district engineers from our own department, in addition to ex-Chief McAfee, who has a national reputation as a successful fire fighter, and several experienced chiefs or assistant chiefs from New York, Philadelphia and other cities.

With a sufficient force of firemen and sufficient apparatus to cover the van and the flanks of the fire line, and to skirmish ahead of it, working intelligently and fearlessly with first-class apparatus and an adequate water supply, and then failing to stop the fire, the next question that naturally arises is: Would the work of these men have been any more effective in stopping the fire with an independent high pressure fire service system such as has been installed in Philadelphia and other large cities in this country? Assuming such a system to have been installed in Baltimore, completely covering the burned district and embodying all of the most desirable features that the latest experience and development would suggest, the greatest advantages for fire service that could have been claimed for it, as compared with what our ordinary water supply system offered, it seems to me, would be, that more streams of a somewhat larger diameter and at a somewhat higher pressure would have been available for concentration at any one point, that these streams could have been more quickly brought into play, and that the same force of firemen could have covered a greater area or handled more streams at any one point. In an emergency of such magnitude, involving so many elements of uncertainty one hesitates to venture a positive opinion as to what would have resulted with a different system or a different method of procedure. Nevertheless, I believe that it is extremely doubtful, in view of the peculiar conditions under which the fire originated and spread, if an independent high pressure fire service system, with the advantages I have mentioned, would have enabled the firemen to stop the fire before it could burn itself out. The peculiar conditions I refer to are as follows:

The fire started in the heart of the wholesale business section on Sunday, in the middle of the day, a condition favorable to its gaining considerable headway before discovery.

It originated in a building having large floor area with no fire walls, large area of window openings, no automatic fire service, and filled with inflammable materials; a condition favorable to the explosion that caused the building to collapse and scatter flaming debris all over the adjoining property before any fire apparatus could be brought into play.

This building was on the northeast corner of a block and consequently the high buildings on the three opposite corners were all directly exposed to its flames, driven by a wind blowing about twelve miles an hour from the southwest; thus in a very few minutes the fire was communicated to three other blocks.

Only a few minutes after the explosion of the building where the fire originated, an iron safe full of gunpowder, on the sidewalk in front of a hardware store, directly opposite the Hurst building, on Hopkins place, exploded with such force as to shatter nearly all the windows in the neighborhood, thus giving the flames an immediate opening into several buildings.

The result was that six or more buildings in four different blocks were on fire before any fire apparatus could be brought into effective play, and the flames spread so rapidly that one fire-engine had to be abandoned in the street where the fire started.

Inside of an hour from the start, the wind increased in velocity to about 20 miles an hour, and in three or four hours, before the first outside company was in position to aid our firemen, the fire covered an area about three blocks long and two blocks wide. From noon on Sunday until the fire was over the wind held a velocity of from 15 to 25 miles an hour, with a maximum velocity for short periods of 30 miles an hour.

All Sunday night and Monday morning it frequently occurred that, in attempting to use hydrants a block ahead of the main fire and in line with the wind-driven flames, the firemen and horses would be singed by the heat before they could attach the hose, and would have to move; and at various times single buildings were on fire several blocks ahead of the main body of flame. All streets in the main line of fire were, without exaggeration, a solid wall of flame from the pavement to the roofs of the buildings. The heat was so intense as to completely consume everything combustible, even wooden sleepers entirely embedded in concrete floors.

Under such conditions one cannot but believe that such advantages as an independent high pressure fire system would have offered would have made very little, if any, difference, either in the rate of progress or the extent of the fire. In stating this conclusion, I wish to emphasize that I have a full appreciation of the value of such a system. I believe that in the great majority of cases, with proper provisions, it would be much more effective than the fire-engine service, and I am frank to say that I believe it would be very much to our advantage to have such a system in Baltimore.

2.—AS TO THE EFFECTIVENESS OF PRIVATE FIRE SERVICES IN PROTECTING PROPERTY.

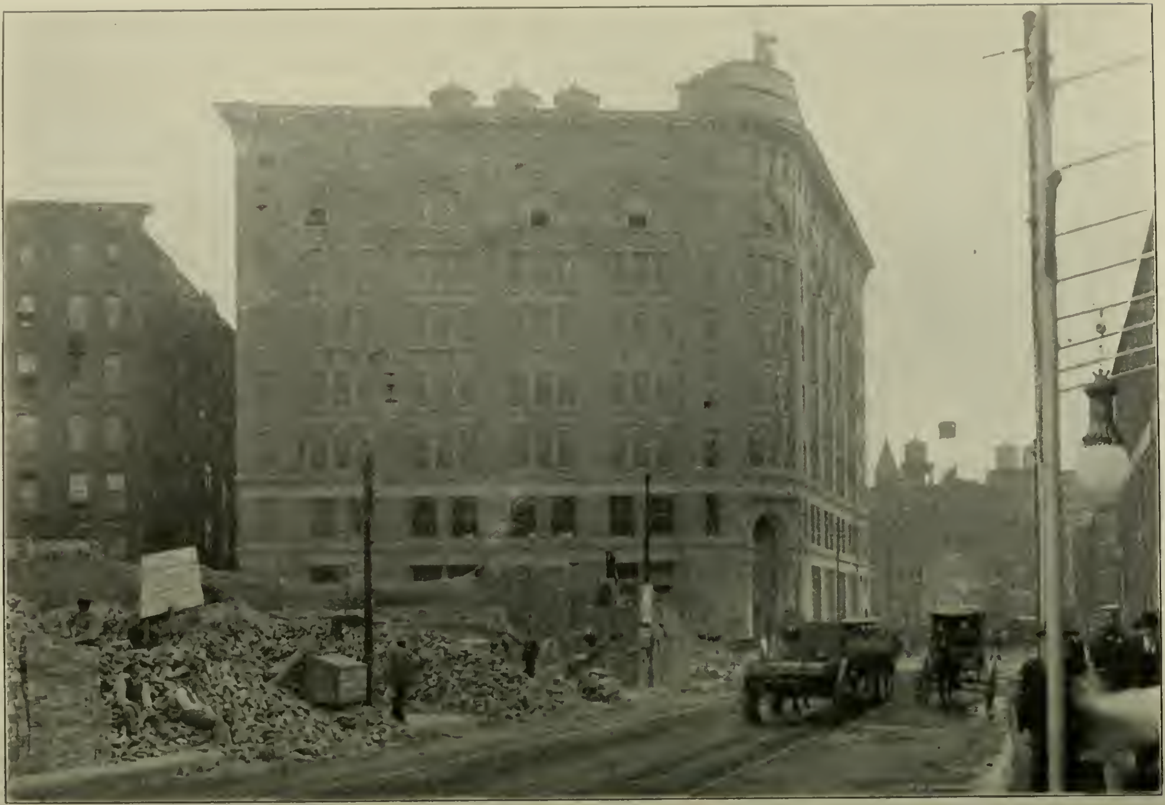
We have in Baltimore, as there are in all large cities, about every kind of private fire service fixtures, including standpipes, sprinkler systems, fire pumps, tanks, hose connections and private hydrant lines. We have also nearly every variety of fire service connection from our mains, except that we have no connections used exclusively for fire service that are metered. We have small standpipe lines branching, from a large metered domestic service connection, inside of the meter; large fire service connections with a small metered branch for domestic service; large connections used both for domestic and fire service, with a sealed valve and a metered by-pass around it; and connections exclusively for fire service with no meters on them. We have no record of the first class of fire service connections as they have been put on by the property owners without notice or application to the Water Department. We have not objected to this class of connections as they give us no trouble, it being impossible for water to be used for any purpose without registering on the meter, and we have never, previous to the recent big fire, been asked by any property owner having such a service to make a rebate from his meter bill for water used for fire service. We have a complete record of all the other classes of fire service connections mentioned, with all information in detail as to the kind, numbers, size or capacity of all fire service fixtures supplied by those connections.

In the burned district the great majority of fire services were of the first class mentioned, that is, a tap off from the main meter supply to a standpipe of two inches or smaller diameter. There were a few buildings having larger standpipes. Nearly all of the larger stores and factories and the tall office buildings had fire pumps and tanks. About half a dozen stores and factories had inside sprinkler systems, and several buildings had outside hose connections. There were no properties with private fire hydrant lines, and none with outside sprinkler systems. In a number of buildings that were burned hose connected to standpipes was used to play on the roofs and walls of adjoining buildings with the sole effect of preventing flaming brands from setting them on fire before the main body of flame reached them. A notable instance of this was at the twelve-story Calvert building, which had six-inch standpipes supplied by a fire pump, with 2½-inch hose connections at each floor. Hose lines from this service played powerful streams all over the buildings adjoining on the west and south, protecting them from catching fire until everybody was ordered out of the Calvert building. The only buildings within the lines of the burned district which were saved from destruction with only slight damage were the one-story bank buildings of Alexander Brown, the Safe Deposit and Trust Co., and the Mercantile Trust and Deposit Co., the Gittings Bank Building, the sub-station of the United Electric Light and Power Co., the new power station of the United Railways Co., and the Government storehouse. Their escape from serious damage was due partly to their fire-proof qualities and partly to some peculiarity of location or surroundings, as none of them had any private fire service and all of them had very little, if any, water thrown on them by fire engines.

The notable instances of the effectiveness of private fire services in preventing destruction of property were at buildings on the immediate margin of the burned district, namely, at the Lloyd L. Jackson wholesale drygoods house, the Baltimore Bargain House (wholesale notions), the shirt and overall factories of Wise Bros., and Oppenheim, Oberndorf & Co., the O'Neill retail drygoods store, the National Casket Co.'s factory and the W. W. Leib planing mill. The location of all of these I have shown on the accompanying map.

THE LLOYD L. JACKSON BUILDING.

The Lloyd L. Jackson building is a large eight-story warehouse, located on the southeast corner of Lombard and Liberty streets, on the extreme southwest margin of the burned district. It has a ten-inch fire service connection from a ten-inch main in Lombard street, supplying the following fire service fixtures: a Grinnell wet pipe sprinkler system with 4,094 heads; an outside dry pipe sprinkler system on the east and south sides with 78 heads; a 750 gallon fire pump with three 2½-inch hose outlets on the discharge; three tanks on the roof holding 7,000 gallons each, and two outside Siamese connections for fire engines. As the fire approached this building from the north, employees started the fire pump, forcing water up to the tanks until they overflowed onto the roof, and kept it up until the roof was flooded and the water overflowed the cornice on the exposed north side of the building, thus forming a water curtain which effectually kept the flames from getting a foothold on the cornice or in the windows of the upper floors. A hose pipe was also attached to one of the 2½-inch discharge outlets from the fire pump and run up over the roof to the exposed side of the building, from which a stream was played on the Jackson building itself, also on the building across the street, which burned, and also on the building adjoining the Jackson building on the east, which was saved. This was

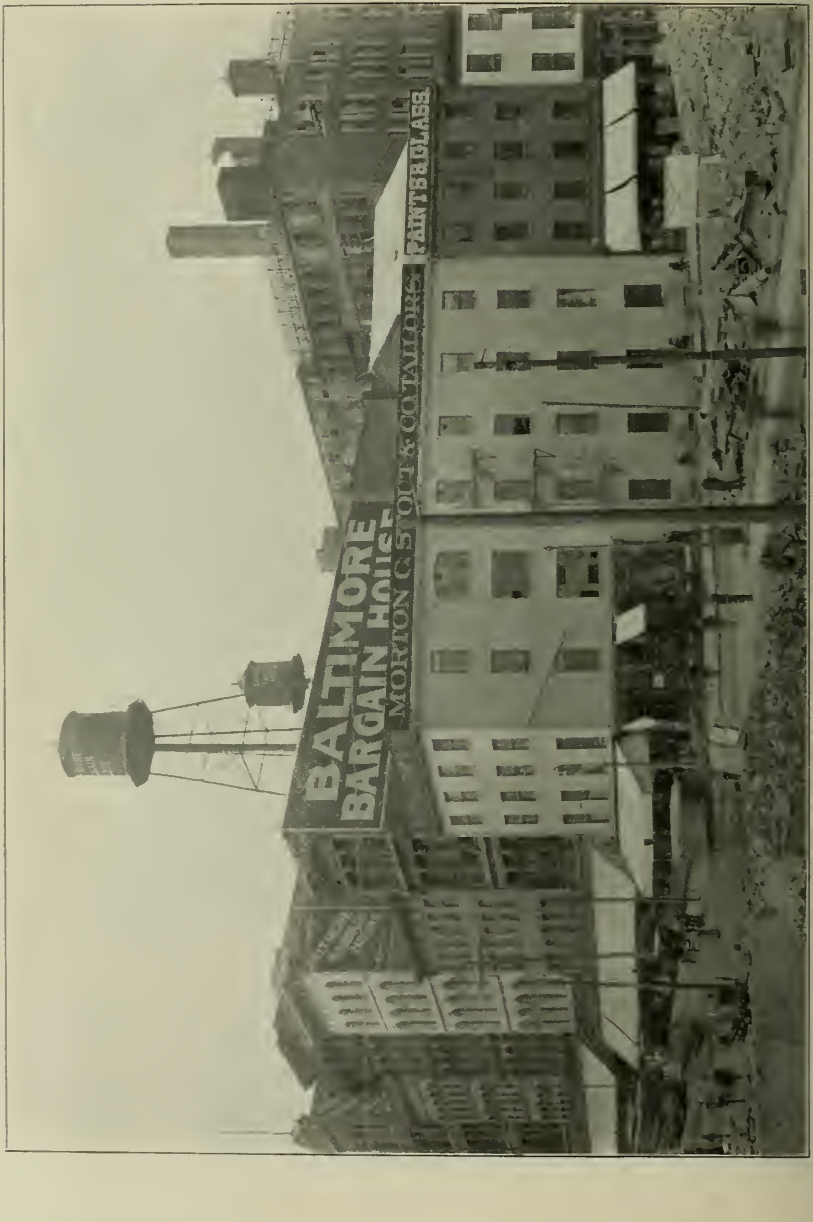


BALTIMORE, MD., AFTER THE FIRE OF FEBRUARY 7TH, 1904.
Lloyd Jackson Building, from Liberty Street, South of German Street.

kept up continuously from about 2 o'clock Sunday afternoon until the buildings across Lombard street were completely destroyed and all danger past. The only damage to the Jackson building was the slight charring of a few window frames and the cracking of some glass on the exposed north side. While it is true that a fire-engine helped to protect the lower floors by playing continuously on the north side, and that the wind was in a direction to blow the flames away from the building, yet there is no question but that this building would have been destroyed if it had not been for the work of the private fire service.

THE BALTIMORE BARGAIN HOUSE.

The Baltimore Bargain House is a group of seven four and five story buildings on the north side of Baltimore street just west of Liberty street, next to a lower four-story building on the northwest corner. It was exposed not only to the flames from the lower building, which was partially burned, but also to the showers of sparks and flaming brands from the mass of burning buildings to the south and southeast. These buildings have more fire service equipment now than they had at the time of the fire. They had then two six-inch fire service connections from a ten-inch main in Garrett alley in the rear, supplying the following fixtures: a Grinnell wet pipe sprinkler system with 2,291 heads; two 15,000 gallon roof tanks; a 2½-inch standpipe with one 2½-inch hose outlet on each floor, and two outside Siamese hose connections. Shortly after the fire started, employees of this firm ran a line of hose from one of the standpipe outlets on the top floor to the roof and played continuously on the roofs of these buildings and on the lower four-story building on the corner. By this means they not only saved the Bargain House buildings, but also helped to save the four-story corner building from complete destruction. The only damage to any of the Bargain House buildings was



BALTIMORE, MD., AFTER THE FIRE OF FEBRUARY 7TH, 1904.
From Hopkins Place, Below Baltimore Street.

the cracking of some of the most easterly show windows from the heat.

WISE BROTHERS' BUILDING.

This firm has a large six-story building on Fayette street at the extreme northwest angle of the burned district. It was not directly menaced by any nearby burning building, but by sparks and flaming debris blown from the burning buildings to the south. This building has a six-inch fire service connection from a ten-inch main in Fayette street, supplying the following fixtures; a Grinnell wet-pipe sprinkler system with 1,120 heads; an outside dry pipe sprinkler system on the north and west sides with 66 heads; one 1,500 gallon and two 8,000 gallon roof tanks; and an outside Siamese hose connection on the front. About an hour after the fire started, employees of this firm opened the supply to the outside sprinkler system and with buckets threw water from the small 1,500 gallon roof tank all over the roof and on the front windows until all danger was past, thereby preserving this building from any damage whatever.

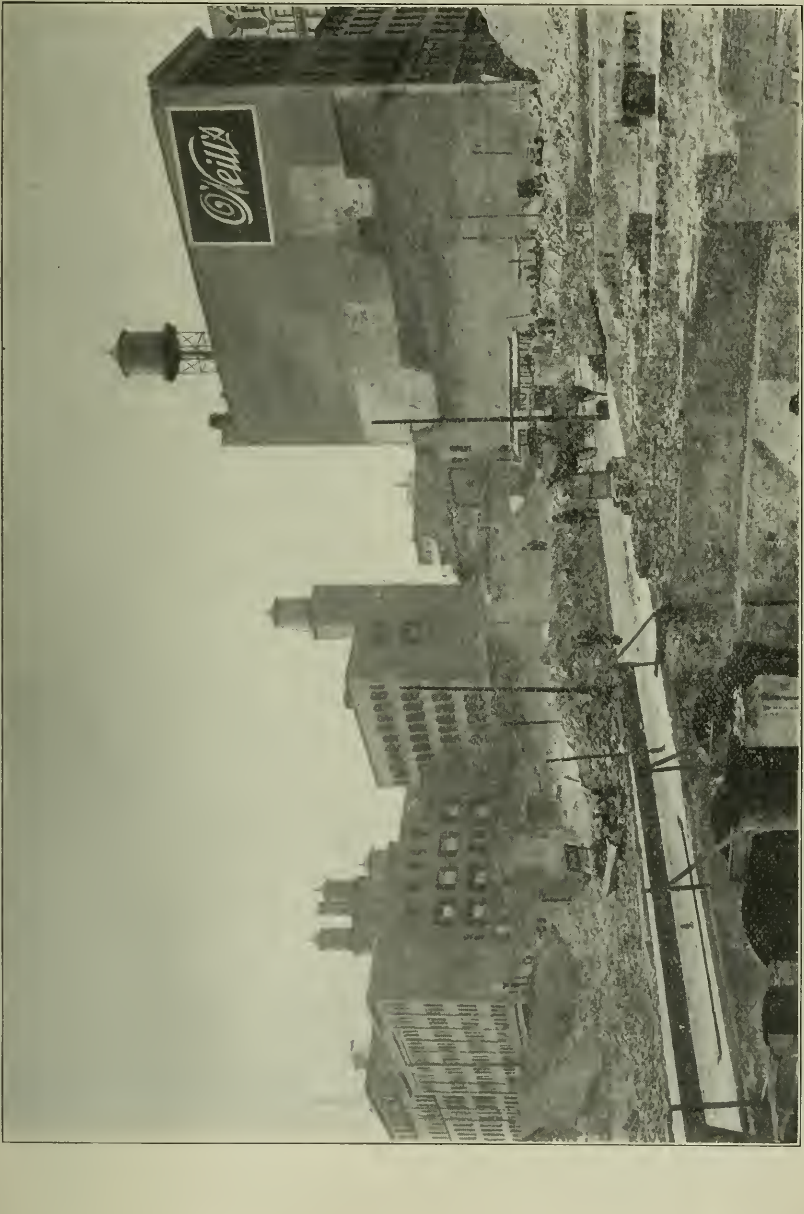
OPPENHEIM, OBENDORF & COMPANY'S FACTORY.

This firm has two large five and six story buildings on the north side of Fayette street just west of Charles street, at the extreme northwest angle of the burned district. These buildings were exposed to flames from a burning building across the street and one adjoining on the east, and also to showers of sparks from the burning blocks to the south. This property has a six-inch fire service connection from a ten-inch main in Fayette street, supplying the following fire service fixtures: a manufacturer's wet pipe sprinkler system with 1,406 heads; two four-inch and two six-inch standpipes with 24 ½-inch hose outlets; two roof tanks, one of 8,000 and one of 10,000 gallons capacity, one tank in the cellar of 28,000 gallons capacity; one Underwriter fire pump with a capacity of 500 gallons.

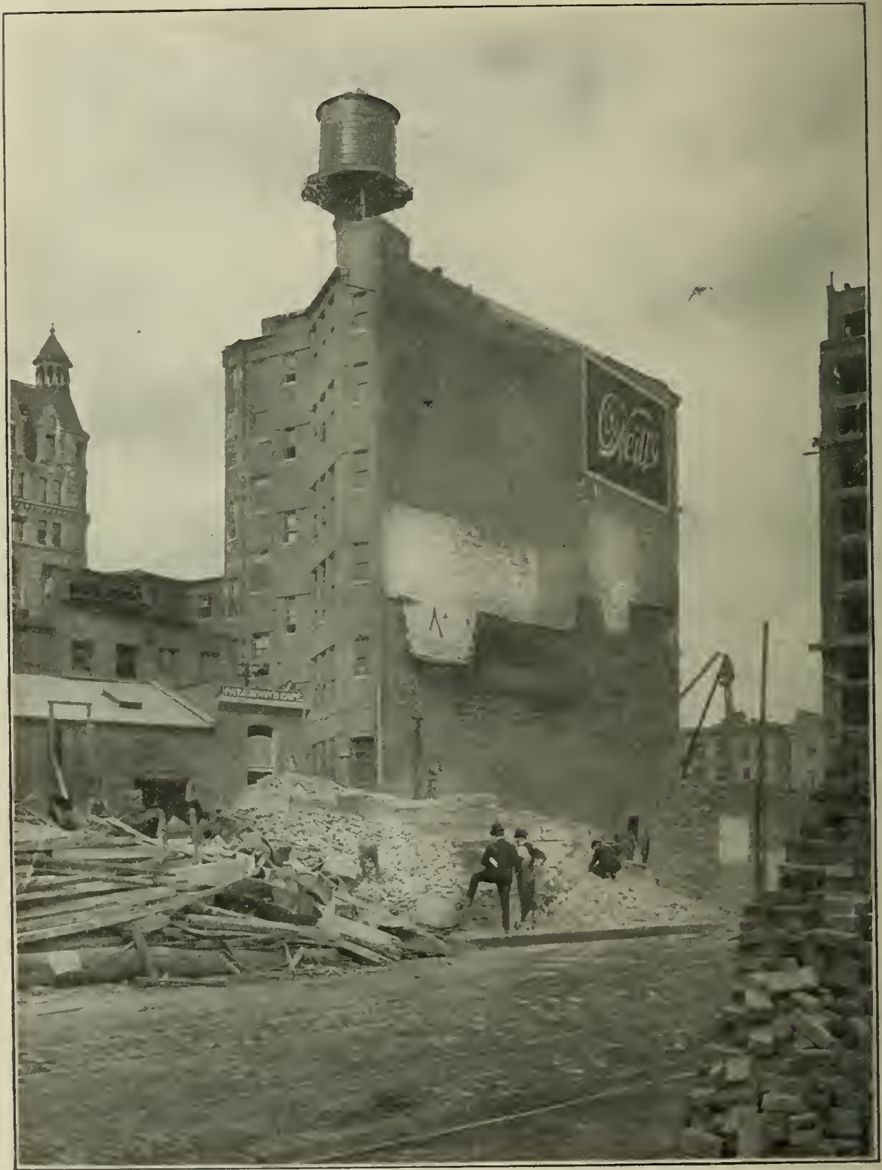
a minute, and four outside Siamese hose connections. Soon after the fire started, when sparks began to fall in the vicinity of these buildings, employees started the fire pump, two lines of hose pipe were connected to outlets on the roof supplied from the pump, and two other lines of hose were attached on one of the upper floors to outlets on another standpipe, taking supply direct from the city main. Streams from these four lines of hose were played all over the exposed portions of these buildings and on buildings immediately adjoining and across the street. As the main body of flame drew nearer the tanks were pumped to overflow onto the roofs until water overflowed the roofs at the cornices, forming a water curtain on the exposed sides, as at the Jackson building. When the building adjoining these on the east burned, the flames broke through some doors and windows on the lower floor of one of these buildings and started a few of the sprinkler heads. The water from these sprinklers soon put out the flames. This was the only damage done to these buildings. It is true that all of the numerous windows on the east side walls were protected by fire shutters, but very little, if any, water was thrown on the buildings from fire engines, and the Fire Department admits that they were only saved by the effective work of the private fire service.

O'NEILL & COMPANY'S STORE.

This firm has two buildings at the southwest corner of Charles and Lexington streets, one old four-story building on the corner and a new six-story building adjoining on the south. These buildings were more severely attacked than any others of those I am considerering, being directly in the path of the wind driven flames and exposed to burning buildings adjoining on the south and southwest and across Charles street on the east. They have an eight-inch fire service connection from a ten-inch



BALTIMORE, MD., AFTER THE FIRE OF FEBRUARY 7TH, 1904.
From Baltimore Street and Charles Street, N. W.

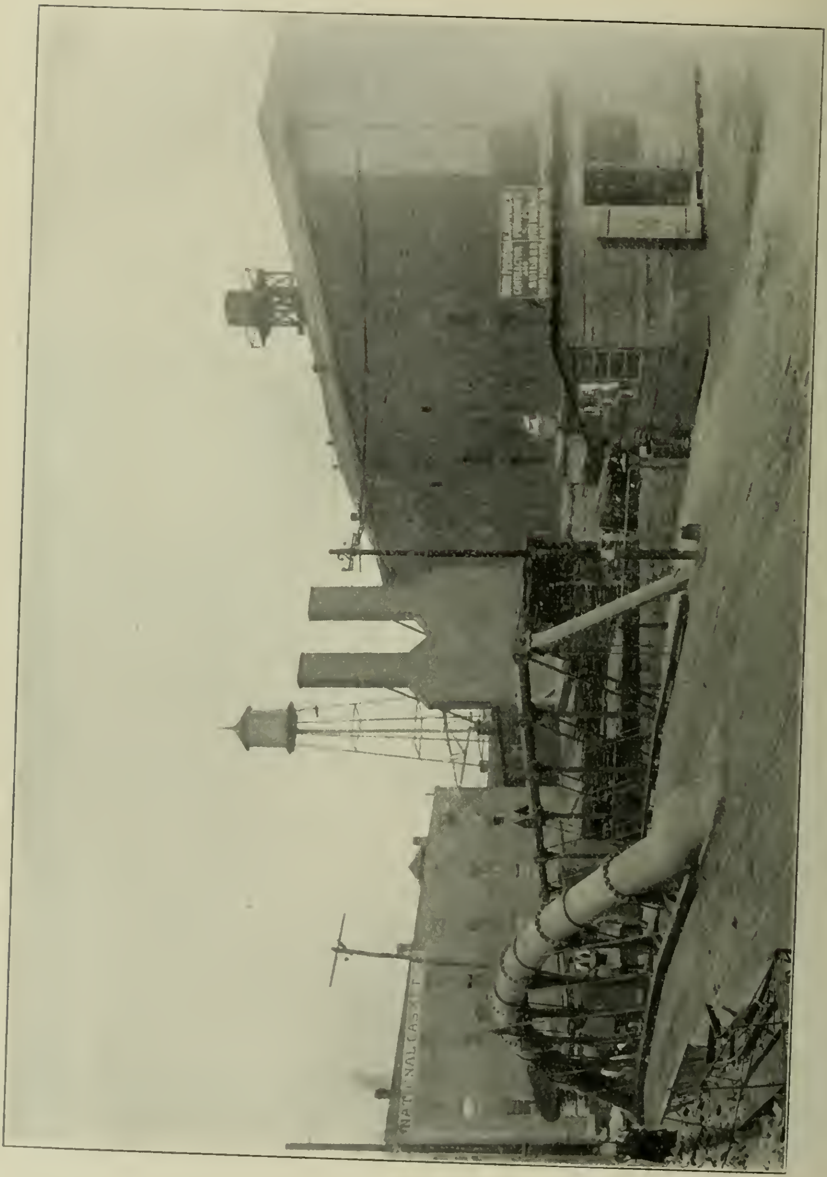


BALTIMORE, MD., AFTER THE FIRE OF FEBRUARY 7TH, 1904.
Rear of O'Neills, from Fayette Street and McClellan's Alley.

main in Lexington street, supplying the following fire service fixtures: an inside Grinnell wet pipe sprinkler system with 955 heads; a 15,000 gallon tank on the roof, an outside sprinkler system on the west side with spray heads over each of the eighty-six windows on that side, and two outside Siamese hose connections. At about 6 o'clock Sunday evening, when the fire approached the vicinity of these buildings, employees of this firm opened the supply to the outside sprinkler system. Fortunately this property was efficiently protected from the flames on the south side by having on that side a blank fire wall of brick laid in cement. A fire engine company helped to protect the exposed front of these buildings, but the fire attacked the cornice of the six-story building and ate its way into the roof, where it was put out by the automatic action of 9 sprinkler heads located in the space between the roof and the ceiling at the top floor. The outside sprinkler system saved the buildings from any damage whatever in the rear, and the only damage sustained in addition to the burning of the cornice mentioned, was the partial burning of the roof tank and the cracking of some of the show windows. It is generally conceded that the sprinkler system was the main instrument in saving these buildings from destruction, and that if they had burned, a great many other buildings in that vicinity would have been destroyed.

THE NATIONAL CASKET COMPANY'S FACTORY.

This firm has three large buildings, a small stable, and a lumber storage yard on the east bank of Jones' Falls just south of Lombard street. This property was exposed to the wind-driven flames from burning buildings on the west bank of the Falls about 100 feet away and from the burning Lombard street bridge; and also to flames from the burning roof of a private house adjoining the property on the east. They have a six-inch fire ser-



BALTIMORE, MD., AFTER THE FIRE OF FEBRUARY 7TH, 1904.
From Lombard, West of Falls.

vice connection from a ten-inch main in Lombard street; supplying the following fixtures: Grinnell wet pipe sprinkler system with about 700 heads; a 10,000 gallon tank on a high iron tower: a 3,000 gallon tank on the roof, and an outside connection for fire engines. They also have running from the regular metered domestic supply two 2-inch standpipes; each standpipe having a 2-inch outlet and 50 feet of hose at each of the five floors of the two buildings. Early Monday morning, when the fire reached the vicinity of this property, employees of the firm ran out two lines of hose from the standpipes with which they played all over the buildings and lumber piles. Some slight assistance was given for a short time in protecting these buildings by one out-of-town fire company. Although these buildings caught fire at three or four different places at times, the only damage sustained was the burning of some sawdust in a vault. This firm is convinced that their private fire service saved their property from destruction.

M. W. LEIB'S PLANING MILL.

This plant consists of a large three-story mill and small office building and a lumber yard, located at the northwest corner of President street and Canton avenue, just east of Jones' Falls. The plant was exposed to the sea of flames and sparks driven by the wind from burning buildings on the west side of the Falls about 200 feet away. It has a six-inch fire service connection from a ten-inch main in President street, supplying the following fixtures: a manufacturers' wet pipe sprinkler system with 900 heads, and a 10,000 gallon roof tank. There is also a two-inch standpipe with a two-inch hose outlet supplied from a two-inch metered service. About noon on Monday, when the fire reached the vicinity of this plant from the northeast, employees of this mill ran a hose line from the standpipe and played all over the buildings and lumber piles, by this means saving the plant from any damage whatever.

FIRE SERVICE AT OTHER PROPERTIES.

In addition to the properties I have enumerated which were more directly exposed to the flames, there were several buildings, not quite so close to the margin of the burned district, and consequently not directly exposed to the flames, but exposed to the showers of sparks, which have fire services that were used effectively in protecting the buildings themselves and the adjoining properties. Prominent among these were: the six-story hat factory of Townsend, Grace & Co., on the south side of Fayette street, just west of Liberty street; the seven-story Smith building on the east side of Hanover street, just south of Lombard street, used as a factory and office building; and the factory of the Baltimore Waste Company, on the south side of Stiles street, near East Falls avenue. The first two of these buildings had fire pumps, the Townsend, Grace Co., and the Waste Company buildings had inside wet pipe sprinklers, and all three of the buildings had tanks and standpipes. At each of these buildings employees ran out hose lines and played streams on the buildings themselves and on adjoining properties, thereby saving all of these buildings from any damage whatever.

It is thus apparent that private fire services were of incalculable value in protecting property from destruction during the great fire of February 7th and 8th. It is generally conceded that they were mainly responsible for saving the seven properties that I have enumerated, and that they materially aided in the protection of some adjoining buildings. Nobody knows how many more buidings in the vicinity might have been destroyed with additional millions of dollars loss, if these properties had burned, but these alone with their contents represent a valuation of considerable over $5,000,000.

The lessons to be drawn from this experience would therefore seem to warrant the conclusion that private fire services are of great mutual advantage to the owners of property, the insurance companies, and the city in general; also that any water department or water company is justified in granting all reasonable requirements of the Underwriters Association in regard to such services, that the limitations of the water works system will permit.

3.—AS TO THE POSSIBILITY OF WASTE FROM BROKEN WATER PIPES IN BUILDINGS DESTROYED BY FIRE TEMPORARILY CRIPPLING THE WATER SERVICE.

Some of the experts who have investigated the experiences of this fire have expressed the opinion that the most instructive suggestion which it affords in relation to water service is as to this possibility. There were, in round numbers, about 1,400 separate buildings destroyed, nearly every one of which had at least one service connection and many of which had two or three service connections. Although the burned district was entirely a business and manufacturing section in which there were only a few residences, the great majority of the buildings were small stores and warehouses, having only small service pipes of one inch or less diameter. As to service pipes over one inch in diameter, there were in the burned district, about 40 1½-inch, 40 2-inch, 165 -3-inch, 60 4-inch, and 15 6-inch, but no connections over 6 inches in diameter. It is impossible for me to state exactly how many of these supply pipes were broken during the fire as hundreds of them are completely buried by the debris. In attempting to stop the leakage immediately after the fire it was in many cases even impossible to get at the stops on the service pipes at the curbs, on account of the debris from the burned buildings, and consequently we had to shut off the mains in some streets. We do know from observation, however, that hundreds of the small service pipes and nearly all of the large service pipes were broken, except those in the buildings I have enumerated that were saved from destruction, and those in the banks and office buildings where the walls and floors were left standing.

As to the amount of waste from broken service pipes, I can only give an approximate estimate. As we had the great majority of the broken services, including nearly all the larger ones, shut off by the end of the week of the fire, the amount of waste after that was comparatively small, and I will therefore only consider the waste for that week. We know from our Venturi meter readings, as I have previously stated, that the total excess of consumption due to the fire for the week from February 7th to 13th, inclusive, was in round numbers 170,000,000 gallons. This was the excess consumption over that of the previous week. To obtain the total amount of water used for fire service and wasted through broken service pipes for the week of the fire there should be added to this amount the normal weekly consumption of the burned district, as there was practically no domestic consumption in that district after the fire started. This amount we estimate from meter records to be about 22,000,000 gallons. Consequently the total amount of water used in fighting the fire and wasted through broken service pipes, for the week of the fire, was about 192,000,000 gallons. Subtracting from this amount the estimated amount of 70,000,000 gallons used for fire service, we have about 122,000,000 gallons as the amount wasted during the week of the fire through broken service pipes. Of this amount we estimate that the maximum amount run to waste in any one day of the week, which was, of course, in the first twenty-four hours after the fire was over, was about 21,000,000 gallons, or about 33 per cent. of our normal daily consumption at that time. This very large amount of waste, in addition to the amount drawn for fire service and for ordinary domestic consumption, did not seriously effect our water service as I have shown, simply because of our having such a very great excess of storage, pumping and distributing capacity over what the ordinary domestic consumption would require. It did, however, prevent our being able to increase the pressure above the normal in the low service section of the burned district in the later hours of the fire. It also materially reduced the pressure in some sections of the city adjoining the burned district, immediately after the fire was over.

It is evident that in some cities where the amount of storage, pumping, or delivering capacity of the water works system is not so much in excess of the normal demands for domestic consumption, as it is in Baltimore, such a sudden and proportionately large increase in the consumption, for fire service and waste through broken pipes, would have seriously crippled the water service with possible disastrous results.

To summarize, therefore, the deductions which from the viewpoint of a water works official, I draw from this experience:

1. There are some fires which no water supply system, no matter how adequate it may be, will put out.

2. Private fire services can do very effective work in protecting property and their installation should therefore be encouraged within reasonable limits.

3. Every water supply system should have a liberal excess of storage, pumping, or delivering capacity over the demands for ordinary domestic consumption to prevent the very large increase in draught for fire service and waste from crippling the service in such emergencies.

QUESTION BOX.

PRESIDENT SHERRERD: The next regular order will be the consideration of the Question Box.

SECRETARY DIVEN read the following question:

"What type of street pavement is best adapted to the public service, especial consideration being given to opening trenches through pavement, to make repairs to mains, laying service pipes, extensions to mains, etc.?

"The interrogator would be pleased to learn the experience of members in relaying of asphalt, brick, Belgian blocks, wood pavement, etc., which had been torn up by water departments."

SECRETARY DIVEN: I would suggest that any member may submit written replies to the foregoing. The next question is by Mr. Bemis:

"What is the best method of protecting meters from frost in out-of-doors settings? Is anything cheaper than a brick vault practicable?

"If a service pipe is frozen in the ground above the frost line, how far, if at all, will the freezing extend to portions of the pipe below the frost line?"

I have one written answer to one of those questions, submitted by the city engineer of Great Falls, Montana, giving a description of the methods of settings there and drawings. It is practically the same as that recommended by Mr. Bemis, with the exception of the employment of a wooden box instead of a tile box, and the bottom of the box below the frost proof inner cover is filled with dry sand or sawdust filling. Just before I came away from home my meter man came to me and said that a box constructed somewhat similarly to that had burned up. The desciption is here and might be printed.

MR. D. L. ELLIS (by letter): Great Falls, Mont. (Municipal plant.) Installed about 110 meters during the past year. Twenty-five of these were set outside of buildings in wood vaults with iron frame and covers. The sides of the vaults were made of 2″ planks, the tops of the meters were brought up to within about 15″ of the surface of the ground, a wooden lid with a heavy felt pad on the under side was set just above the top of the meter. The space around the pipes and around the body of the meter up to the water line was filled in with dry sand or sawdust, and although we had the longest continued period of cold weather ever experienced here, we did not have a single meter freeze which was set in this way.

These wood vaults are considerably cheaper in first cost than anything else that we can use here; sewer pipe is very expensive here on account of having to be shipped a long distance, and the funds of our department would not admit using it. Members can compare the prices of material in the statement of cost, with similar materials in their localities, and compare the costs. We expect that the wood vault will last from 10 to 12 years, at which time we can probably afford to put in something more permanent to replace them.

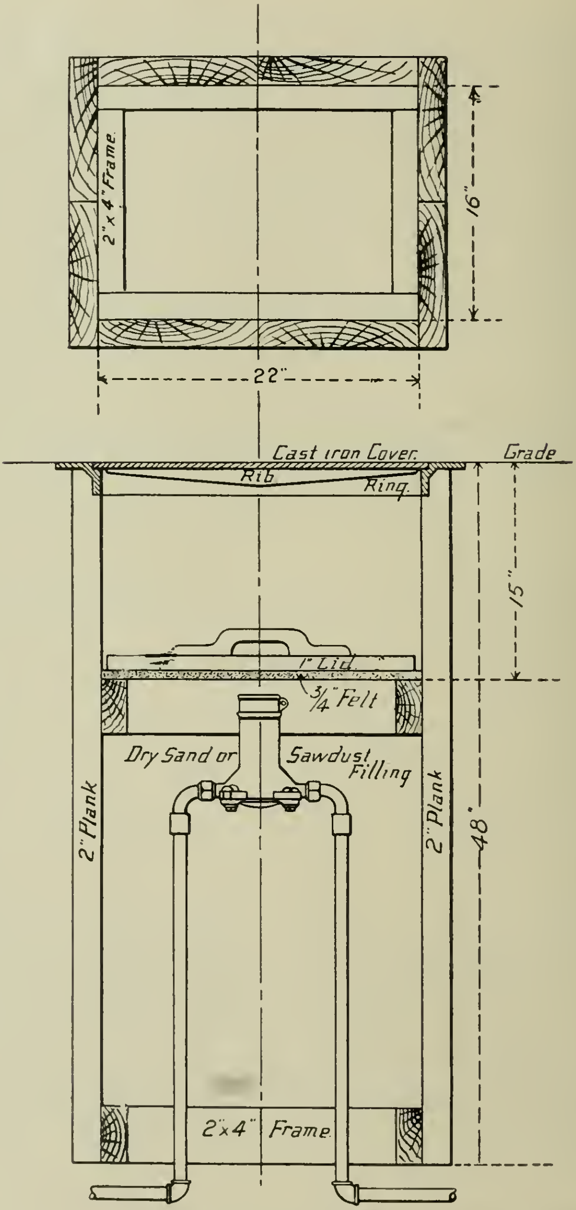
We also think that the wood is a better non-conductor of cold than brick or pipe, and will make a better protection against frost.

The following is the average cost of putting in the wood vaults:

Cast iron ring and cover	$5.00
Lumber at $18 per M	1.62
Nails	.10
Felt pad ¾″ thick, 16″x22″	.34
Labor making vault	.41
Labor excavating and placing	1.25
Total	$8.72

Brick or pipe vaults even of a smaller size would cost here about twice this amount. The town is yet very new and future improvements and buildings may, of course, make necessary changes in the settings of many of the meters before the wood vaults rot out.

Local conditions will necessarily guide the water works manager in selecting the proper form of out-of-door settings for meters.



PLAN OF WOOD VAULTS FOR SETTING METERS, WATER WORKS GREAT FALLS, MONT.

A question proposed by Mr. Tucker, with reference to the effect of flushing upon pavements, was read by the Secretary.

Mr. Tucker: We have in our city three kinds of pavements—asphalt, stone and brick. The cleaning of the pavements is under the supervision of the Board of Health, who have been cleaning the asphalt pavements by flushing them from the fire hydrants through some four or five hundred feet of hose with little wheels underneath to prevent the wear of the hose, using a 1½" nozzle. The other pavements were cleaned by street sweeping machines, the work being done at night, but they have abandoned both of these methods and adopted, I might say experimentally so, the compressed air flushers. They use a great deal of water in both methods, both with the compressed air flushers and washing the asphalt pavements with hose. The Water Commissioners think they use entirely too much water in either method, and I agree with them.

My reason for asking the question is that I desire to get the modes used in your respective cities. In visiting different cities I have never seen streets flushed with water to the extent to which they are in our city.

If anyone present can give me any information on this subject, I will be pleased to get it.

Mr. Benzenberg: The method which I witnessed here of washing or cleaning streets by flushing struck me immediately as being very detrimental to any kind of pavement. The water is discharged under considerable force and pressure, and when so discharged is sure in time to disintegrate the top surface of any asphalt pavement by removing the finer particles of the asphalt surface, leaving a roughened surface, which will grind up and disintegrate by the passage of wheels over it, thus rapidly deteriorating the saphalt pavement. It is the same with the joints of either a brick or stone pavement, whether they are filled with sand or concrete. Tar filling would also be subject to the same action from jets of water under pressure, and this filling will be disintegrated the same as in the case of asphalt pavement. In coming along to where they had been flushing the block pavement yesterday, or perhaps early this morning, I saw large bodies of sand scattered along the gutter, which was being removed by the street cleaning men. It was clean sand, not mud or road detritus, or anything of that kind, but sand that had evidently been washed out of the joints. That method of washing or street cleaning is detrimental to the pavement, besides being wasteful of water. It appears to me that the better way of cleaning such streets would be by sweeping them and carting away the debris, and occasionally washing the asphalt pavements, because asphalt is so smooth that you cannot remove the fine dirt and dust unless a very fine and close grained broom is used, otherwise the dust will not be removed and the wind will lift it and make a serious nuisance of it. Such has been my experience.

MR. EGGERS: I would like to ask what effect the washing of streets by flushing has upon the sewer system of the city?

MR. TUCKER: I would state that our surface water does not go into the sewers at all. We have in our city several natural water courses, which we term bayous, and into them all surface water flows, and thence into the river.

MR. EGGERS: In our city we have sewer catch basins. We have experimented with flushing the streets, and found that our sewer basins would very soon be stopped up, causing us to spend a great deal of money in cleaning out the catch basins on that account.

MR. BEMIS: I would merely suggest that here is a capital illustration afforded of the value of the discussions in this Association. Here is a man like Mr. Benzenberg giving us the benefit of his engineering experience. I am going back to Cleveland to stir up our board of public service who have been lately using these high-pressure carts for cleaning the streets, and which we are here informed are going to destroy our pavements. At Mr. Benzenberg's suggestion I think it is about time that we take up that matter.

MR. PENNEY: Last year our board of public service started out to wash streets from hydrants, and before they got through with it our pavement was nearly ruined. It is a brick pavement with cement joints, and the cement was carried out by the force of the water. They are no longer washing the street now, but are using "white wings."

MR. KIMBALL: While we in Knoxville do not have asphalt pavements but do have brick pavements, yet so long as the city gets its water without cost, it thinks this a very cheap way of cleaning the streets. Several observations that we have made as to the quantity of water used has shown us that it takes on an average 500 gallons of water for every 100 square yards of pavement washed—not a very large amount—but it is used under pressure, and the nozzles range from an inch to an inch and a quarter, with the regular fire hose. I have found, although I do not know whether the city has discovered it, that this method is washing out the joints between the bricks, the joints being the ordinary tar or asphalt joints, so called, although of nothing else than coal tar. It is quite noticeable that the edges of the bricks after the filling between has been washed away, are being worn off by the travel. It thus appears that, outside of the cost of cleaning the streets by this method, the wear and tear or depreciation of the pavements is increased over and above what it would be were the streets swept, as no sweeping would remove this tar from the joints, which, by remaining, would protect the edges of the brick.

In regard to the sewer question, Knoxville has storm sewers into which much of the debris from the streets is washed and after every two or three washings all the catch basins are full and it requires a gang to go around with carts and clean them out manually. I cannot state how that compares with the cost of sweeping, because I have never had any work of that kind under my charge. The expense of washing, so far as the water itself is concerned, you may figure at your own prices, 200 square yards taking about 1,000 gallons of water, and a flushing gang of four men, who usually go over about 10,000 square yards as a night's work. They do the work at night and use no horses.

MR. BOARDMAN: It does not matter at what point sand is introduced into a jet, whether it is on the surface where the jet strikes, or any portion before it gets there, every one knows that the effect of a sand blast is very great. I think that any board of public works will at once recognize that when their attention is called to it, and this might make them hesitate to experiment with cleaning streets under pressure.

The next question is: "What means can be successfully employed to prevent or remedy condensation or deposit on under side of glass or on figures, which obscure meter readings?"

MR. BOARDMAN: That question was suggested to me because of the difficulty encountered in Southern cities, where my practice is largely located, by a deposit on the under side of the glass and on the figures of the dial, of moisture. We have no cellars, practically, in the South, and our meters have to be placed in the ground, which is seldom of the same temperature as that of the air; and when the temperature is lower and the air is at all saturated with moisture, no matter with what care we have the glass over the meter put in, or how hard we try to make it absolutely air tight, there is considerable condensation on the under side of the glass, and our conscientious meter readers, rather than miss reading a meter or guess-ing at it—as they probably might do—frequently think it is best to simply break the glass, with results that any engineer can understand. The repairs to meters are very considerable. This does not apply so largely to the meters with the old-fashioned dial, because if you can see the hands at all or any portion of the dial, you can pretty accurately guess its reading, but on straight reading meters it is sometimes utterly impossible to read the meters because of the condensation on the under side of the glass. A little glycerin will remedy this for a time, but it soon deposits a white sediment upon the dial itself that is quite objectionable and a little more difficult to get rid of than the condensation under the glass. Some pour a little alcohol in and set fire to it. I do not think the mixture of the meter reader and alcohol is at all a good one. These troubles that we have had have suggested this question, and I hope that some of the meter men present may be able to suggest a remedy of an inexpensive sort. I would like to hear whether others have been troubled as I have.

MR. MANVILLE: We have had the same trouble. After following several suggestions with poor results, we used old burlap bags, costing us about a penny each, which we placed over the meters. This we found to do away with the moisture on the dial.

A MEMBER: Does it absorb it?

MR. MANVILLE: It equalizes the temperature, and thereby removes the cause of condensation.

PRESIDENT SHERRERD: Do you have to change these bags?

MR. MANVILLE: No, sir.

SECRETARY DIVEN: I might suggest a little slaked lime to absorb the moisture.

MR. MANVILLE: Our meters are placed about two feet below the surface. Only sufficient burlap to cover the meter well is necessary.

MR. HOPKINS (by letter): We have about one hundred and fifty meters, mostly on large consumers. I have had some trouble with moisture under the glass, often forming a bubble and so magnifying the figures as to make it difficult to tell what they are. In some instances I have had to remove the cover in order to read them.

I found that when the men put the packing around the meters to prevent freezing they used fresh manure—often just throwing it in on top of the meter. This soon became a hot bed, and I think is the cause of the moisture under the glass, and sometimes stains the figures brown, making it still harder to read them.

I removed the fresh manure near the meter and put straw, gunny sacks, paper or any dry stuff around the meter and had no further trouble.

MR. WORRELL: A little piece of burlap or other cloth put under the lid of the meter dial will accomplish the same purpose. It does not require a whole sack.

MR. HOPKINS: We have not very many meters, mostly large ones. It is very difficult sometimes to read them on account of water forming a bubble underneath which so magnifies the figures that you do not know what they are. I have had to take a screw driver and take them off. In several instances I got the glasses broken. I just lay a piece of paper right under the lid, any kind of paper, newspaper or anything I happen to have. I found that worked on the glasses that were not broken better than on the broken ones, of course, and did away with the moisture to a great extent. I also have used gunny sacks, but more to keep rust and dirt off the meters. In such cases I find that we do not have any trouble with moisture.

MR. HARBSTER: I should suggest that dry charcoal put into the box will absorb moisture for a long time.

SECRETARY DIVEN: There is a device on the market—patented by a member of this Association—for cleaning the glasses on meter dials. I had a sample sent to me which I have used successfully. The cap is made to fit tight, the glass being set with putty or cement, to make it water tight. The cleaner consists of a piece of wicking operated by a rod passing through a stuffing box on the side of the cap. This seems to clean the glass, even though the rag may become saturated. It is simple, easily operated, and there is nothing about it to get out of order. I do not know that any meter manufacturers are putting it on meters. The one that I have is for "straight reading" meters, but understand that it is made for all dials.

MR. BOARDMAN: The remark of the Secretary brings to my mind the question of the straight reading meter. I think it is the meter that is coming to stay, just so soon as the manufacturer will give us a running gear that will register as accurately and as durably as the old train of the ordinary meter. Then all of us would prefer to have the straight reading meter, not so much for the benefit of the water company, although it will benefit the water company or department because anyone they send out can read it, even a boy, but it will avoid the frequent complaints that arise from the inability of your customer to read the old-fashioned dial; and it is ignorance that causes more trouble in a water works office than anything else. Any measures that you can take which will enable your customer to check up the reading of the meter readers is a great point gained in popularizing the water department.

I am very much obliged for the information elicited.

PRESIDENT SHERRERD: Are there any further questions that any member would like to submit?

MR. DAVEY: I would like to ask if any of the Superintendents have any trouble with fish dying in impounded reservoirs? We have three reservoirs, the whole aggregating 1,200,000,000 gallons, about the 20th of May each year the fish known as catfish, sunfish and shiners die by the ton, so that when I left home last Saturday I had four men going around the reservoirs picking up dead fish.

The Friday before they picked up nineteen bushels—about a ton.

Now, these fish, as a rule, especially the catfish, have one or more sore spots on them. With some of them the tails will be eaten off; while others appear as if blood poisoning had set in, and the flesh had sloughed off.

The lakes are also stocked with black bass, trout, wall-eyed pike and pickerel; and yet none of these fish die as a rule. This has happened every year since I have been in charge, which is seven years, and it did previous to that time, from about the 20th of May until about the 20th of June each year. After that time we see no more of it until the next year.

It is expensive to pick them up, and it is not beneficial to the quality of the water. If anyone has any experience in this matter I would be glad to hear of it.

Mr. Patton: On three different occasions I had dead fish in our reservoir. That occurred once, and not again for about six weeks. Then it occurred again, and I offered $100 reward for the man who put dynamite in the reservoir—and that cured it.

Mr. Davey: I took some of these fish at one time, packed them in ice, and sent them to the United States Fish Commission at Washington with a letter. In due time a reply was received to the effect that the fish had been attacked by a parasite which had generated from decaying wood in the reservoir. That is high authority, yet I do not think that is the case.

The reservoir that has been built the longest is the least affected in the way of fish dying. In the reservoir built two years ago the majority of the fish that die are sunfish: it is also stocked with California trout, of which none seem to die. The sunfish is native to the water.

All the water from these reservoirs is thoroughly filtered before entering the distributing mains.

President Sherrerd: Our trouble, on the other hand, has been a too promiscuous attempt on the part of the people to take the fish out without direction from the water department. (Laughter.)

MR. DAVEY: Now, then, we are up against this proposition: These lakes have been stocked with state fish, and when I left home we were in communication with the State Board of Health and the State Fish Commission of New York, who have given us permission to remove the fish by seining, and suggest that we place them in some other stream, but the lakes are very rough and it would be almost impossible to seine them out. In response to another communication asking if we might employ any other means to remove them, we have not as yet had permission. We have prohibited fishing in any of the reservoirs, especially since the epidemic at Ithaca and other cities, and are trying to keep the people off the watershed; but the fish are there, and we want to get rid of them.

MR. BOARDMAN: I think the information furnished by the gentleman himself indicates that probably the United States Fish Commission was right. He states that the reservoir which has been longest in use is freest from trouble. The trouble seems to exist as to those fish which live upon suspended matter in the water, and not with the predatory fish, that is, fish which live on other fish. The only fish that suffer seem to be those which live upon the muddy bottom, such as catfish and the like. I think the indication is that there is decaying wood or some such matter in the reservoir, and I would suggest a lowering of the reservoir and a perfect cleaning of its bed, if it is possible.

MR. CONNOR: While we do not take water from any lakes in our town, when we had lakes we had a sort of fish in the lake, many of which died upon the shore in the spring from the fact that previous to that the state game commission prohibited the catching of fish and burned up the fish house. The last two years they have permitted it, and have air holes in the lake. The having of those air holes has prevented a great many of the fish from dying. It did not seem to affect the pike, of which there are a few, or the pickerel in this chain of lakes made into a river, but the other fish that you have named die by the thousands; but since they have allowed them to cut holes in the ice and to fish, they are not bothered with them so much.

MR. BEMIS: I wonder if any here have encountered the popular prejudice against meters because of very small fish lodging against the meter strainers and there supposedly in time being decomposed, the assumption being that the water must be somewhat affected, though perhaps nobody has realized it. We have been encountering that prejudice and have made provision for it. We have been trying to meet it by putting in the very finest mesh fish strainers both where the water enters and where it leaves the reservoir. We use a mesh of about one-eighth of an inch. I wonder if any others who are using meters extensively have encountered any of that popular prejudice? Have you, Mr. O'Shaughnessy?

MR. O'SHAUGHNESSY: We have neither water nor fish in my town. (Laughter.)

PRESIDENT SHERRERD: One matter that I am rather surprised has not been spoken of very extensively at this convention and which I think might profitably be a subject of discussion, is in regard to the thawing out of frozen services by electricity. I really feel that the proceedings of this Association have been particularly valuable to different cities due to the fact that this matter was so thoroughly ventilated in the proceedings of 1897, being then I think brought forward by Mr. Heim of Madison, Wis., as a sequel to the work of Professors Jackson and Wood of Wisconsin University, to whom the thanks of all water works people are due for bringing it forward in the shape that they did. I will be glad to hear from any one as to their individual experience in this matter.

SECRETARY DIVEN: I would say that I used that method very successfully last year, substantially the same as employed by Professor Jackson. The system is too complicated to describe here. It was gotten up by the Superintendent of the Electric Light Department without any knowledge of previous uses. If desired by the Association, I will have him write a full description of it and will include it in the proceedings. Mr. Heim described it in 1898, with the exception of the rheostat.

MR. EGGERS: We thawed out 2,100 frozen services, which was done under the supervision of Mr. Sherrerd.

OWEN T. SMITH: The apparatus which we used consists simply of a transformer mounted upon a wagon, taking the current from the primaries carrying the alternating or incandescent current and transforming it to direct current at 52 volts pressure and then connecting it so as to make a circuit through the service by attaching the wire from one side of the transformer to the service itself and the other wire to the nearest hydrant or service pipe. The first one we tried required eight minutes and the time varied from that up to one-half hour.

SECRETARY DIVEN: In one instance we had this experience: not having a hydrant or valve convenient, we went to another house where water was running, and the water pipe coming in contact somewhere with wood, and the current having a long way to go, the wood took fire and set fire to the house.

OWEN T. SMITH: We thawed a service with steam before we arranged for the use of the electric apparatus, and when we tried to thaw the next door service the first being without water or ice in it we found that we could not do so, this led us to the conclusion that there should be water or ice in the pipes or the electric current would not be so effective.

MR. BEMIS: I have embodied in the report that is printed in the advance copy our experience, which I will not stop to repeat now.

MR. O'SHAUGHNESSY: My experience has not been along lines of electricity in thawing out water services. A few years ago I had a line of pipe across a bridge probably three hundred feet long. It was 10″ pipe and was frozen solidly. I secured a steamer from the fire department, broke the pipe at one end, turned a jet of steam into it, and followed the aperture made with a ¾-inch pipe through which we ran the steam. We thawed the whole length of 300 feet in less than three hours, although it was extremely cold weather. Last fall I had a machine made for steam thawing. It was an ordinary steam boiler placed in an upright position upon a wagon gear, and enclosed much in the same manner as the wagons used to blow out beer faucets; in fact, I got my idea from these wagons. The steam is generated by a gasoline burner, and the men operating the machine leave the shop with from 60 to 80 pounds; they carry about 200 feet of ½-inch hose. The machine is not a cumbersome affair, and is pulled by one horse. It works very successfully in thawing out fire hydrants, no matter how badly frozen; last winter, severe as it was, we had no trouble at all in thawing out the hydrants. We also used it to thaw out a main, a short one, the only one that was frozen last winter. The machine cost about $500 to construct.

MR. PRIDDY: We have been using such a machine set on a wagon with springs. We hitch two horses to it, and carry 100 pounds of steam on the street. We adopted this before the electric business came in. We have no day current anyhow in our town. Our pipes are laid all the way from 6 to 8 feet deep. Where the streets have washed off, only 6 feet deep. We have an arrangement that we can dig right down to the pipe, and bore a hole in there. We have 200 feet of hose, so that we can put on a little steam traveler that will go into ½ or ¾″ hose, with a small jet that will cut a hole through the ice. There are steam jets shooting back that cut the ice as it goes along. It is no trouble to thaw out 200 feet in a short time.

President Sherrerd: In our city of Newark (N. J.) we had 2,100 frozen services, of which we thawed out 2,000 with electricity. Our electrical equipment for this purpose was five wagons, and we are able to thaw out about 200 services a day. The apparatus was arranged practically along the lines suggested by Professors Jackson and Wood and as first used at Madison, Wis. We took the current from an A. C. line of 2,300 to 2,400 volts, and transformed it to about 40 volts. We had some question about the collection of the charges in several cases of leaks, where the owners claimed that the leaks were caused by the electrical thawing. I investigated this complaint pretty carefully, and out of forty or fifty reported I found only two that could in any way be attributed to the use of the current. The other leaks, no doubt, occurred or were manifest after the thawing of the ice, and were due to the ice having burst the pipe, the leak developing when the current thawed the ice out; but in the two cases mentioned couplings at the curb showed signs of melting. We were particularly careful in applying the current to watch the meter so as not to get more than about 300 amperes on the pipe. Those two cases where the couplings melted I am satisfied happened from the fact that the pipe pressed the washer under the coupling up close enough so that although the coupling was not screwed home, the connection was watertight; and in that position there was very little metal contact. That is, the coupling not having been screwed home, the base of the coupling did not press against the shoulder on the soldering nipple and only gave an electric contact just where the coupling hung on the thread, and of course all the current then had to go through one point of the coupling, which heated it sufficiently to melt the coupling. Where the current was passing through the lead service the heat was so diffused that we saw no indications of melting of the lead, and I think it would be a very rare occurrence that a coupling should happen to be just in the position above described. You can see how if a meter was stuck in between the two ends of the pipe so tight that the pressure held the washer up and the coupling had not been screwed home, there would not be a metal contact; but where screwed up metallic contact is certainly established. We got our electricity from the electric light company, and they furnish two men on each wagon, one to make cuts into their high tension lines, and one to watch the apparatus on the wagon.

We had considerable difficulty in adjusting the amount to be charged for this service. We figured it out on the basis of the actual current used, and at 10 cents per kilowatt hour of use it amounted to something around $1.20 per connection, but as we generally make two thaws for one use of the current, the actual amount used would be something over sixy cents per service. After the water department started to use electricity to thaw out the services, the electric light company, which reaches nearly one-half of the state, found so many calls coming in from other towns and cities in their district that they took up the matter of their own accord, and furnished an equipment to plumbers in some of the cities where the plumbers put in the services. (That is not the case with us.) They charged such plumbers $10 for each thaw. So that when we tried to make an adjustment with them they were very stiff. We finally had to come to some compromise, and paid them $4 a thaw, which was, I thought, a great deal more than they were justly entitled to, although their claim was that they had to take all the risks of accidents to their men. The danger was somewhat increased over ordinary line work, because we had so many calls we kept the men working pretty well into dark, and also got them to go out when there was a drizzle, but they didn't work when it was raining hard. I am glad to be able to say that out of those 2,100 services there were only 88 that had been put in recently, that is, during the last nine years; and out of those 88 I am satisfied a very large majority were frozen under the sidewalk, because it has been our practice for the last nine years to put all our services down 4½ feet in the street, and 5 feet at the curb. That is below any hitherto known frost penetration in recent years in New Jersey, or in the metropolitan district. This time the frost got down to about 4½ feet, and in some cases a little deeper than that.

SECRETARY DIVEN: I would like to ask if anybody has used electricity for thawing anchor ice in intakes?

To which inquiry there was no response.

PRESIDENT SHERRERD: I would like to add to my remarks on the subject of electric thawing that the water department charged $5 for each service, of which $4 went to the electric light company.

A MEMBER: Did you allow any rebate for those excessive water bills which occurred at the time you were using electricity?

PRESIDENT SHERRERD: Our rule as to the adjustment of water bills has been to refer the matter to a special committee on adjustment, and to allow up to one-half of the excess as a rebate in the case of underground leaks. On the particular question inquired of, the committee has not decided exactly what position to take. It seems fair to make some allowance, particularly as often there were several families supplied from a service that allowed the water to run to prevent freezing. I might add one thing more in regard to the freezing of hydrants. We had about thirty hydrants that were frozen in one portion of the city where the pipes were laid some twenty-five years ago, and while we were successful in thawing out a hydrant branch, we tried it on one or two, but of course the ground around the branch was so frozen that the branch would freeze up unless you allowed the water to run. So we dug up the others, taking up every third one, in order to get the service going as soon as possible, and refilled with manure around the pipe, and that protected us during the remainder of the winter.

MR. HEEGER: As stated the other day, we had a broken intake pipe, under fifty feet of earth, twenty-four feet of which was natural earth and twenty-six feet of fill. There were three intake pipes thirty inches in diameter that ran from the caisson to the river 200 feet. They broke off last winter about midway between the strainer and the caisson. We have received several suggestions in regard to permanent repairs, but so far have taken no action whatever on it. We put in a temporary intake pipe and have run with that very successfully so far. The suggestion was made and plans submitted to take those three intake pipes as they are now, they are hung on piling the way they were put in, run them out the same way they are and put a concrete foundation under them, laying the pipe on top of a concrete foundation. Then put concrete around and over the three 30″ intake pipes, making one solid mass of concrete 200 feet out. The other plan is for a tunnel and intake pier on the inside of the channel, because we would not be allowed to go in the channel. Then run in one 60″ intake pipe with a tunnel, and then branch off to three going through the caisson, using the pipes and valves now there. I do not know whether any of you have had experience with concrete. We have had our share of troubles this winter and are in no hurry to make permanent repairs. If any of the members here have had any experience in our line I would be more than pleased to hear some of their experiences, and if there are any suggestions will be glad to have them. We are over our difficulties at the present time, but we have two pretty difficult propositions before us now. The bottom is quicksand; we do not know just its exact nature until we get down to it, and cannot do anything until after June, when the river falls sufficiently to get down to it. Our works were built in low land, a fill being made of 26 feet. The fill is the most solid part of the ground, and was rolled every 4 inches.

MR. O'SHAUGHNESSY: I understand that Mr. Cole has a paper and I think he ought to be given the privilege of reading it. I shall refer to it before it is read and state that we have had some experience along that line and it is something that proved very valuable to us. I believe if you would look your plants over you might some of you find that you were in the same condition that we were in when I met Mr. Cole.

PRESIDENT SHERRERD: In regard to the situation at Evansville, Mr. Heeger, I am afraid that it is one that would prohibit any adequate suggestions being made except from a very intimate knowledge of the conditions as they exist there.

MR. O'SHAUGHNESSY: I would not like to give my opinion without a retainer.

MR. WORRELL: I would suggest to Mr. Heeger that he needs the services of a first-class engineer.

THE WATER WASTE INVESTIGATION IN NEW YORK.

By Edward S. Cole.

The recent investigations of water waste in New York City have furnished much new light on the use and waste of water, which should be of interest to all municipalities.

A brief account of these studies is here presented, giving some idea of the general results, and the methods by which they were obtained. A more complete analysis, however, may be found in the reports of Chief Engineer, N. S. Hill, Jr., of the Department of Water Supply, Gas and Electricity, New York City, and in the report of the New York Commission on Additional Supply, 1903.

These investigations were begun in the fall of 1902, and continued for over a year, using pitometer gaugings of supply as a basis. The pitometer as described in technical journals, has given a new impetus to water waste detection, for with its use, it is now a simple matter to measure and record the flow of water in an underground pipe. Starting with this as a basis, it is only necessary by closing the regular main gates to isolate portions of a distribution system, allowing the supply to come in at one or more points where the flow must, of course, be recorded. The enclosed area may be half a mile square, or may consist of a single block; in either case its total supply is found, and, by comparison with the population and the special requirements of the section, we may judge of its wastefulness.

By sub-dividing this area, we pick out small sub-sections or single blocks which have an abnormal rate of supply, as shown by the pitometer. In New York, unfortunately, we found it impossible to fully localize the waste indicated in some districts because of the lack of service cocks. However, the charts showing variations in total supply are highly instructive and valuable.

In the organization of this work, it was necessary to obtain statistics of population by U. S. enumeration districts from Washington, and the figures for frontage and metered revenue from the books of the Water Department, also data regarding the number of houses and families in each of our pitometer districts. A force of house to house inspectors was organized for the purpose of measuring, as far as possible, the visible leakage in plumbing fixtures throughout our districts. These men also measured and inspected roof-tanks, the filling and overflowing of which had an important bearing on our results.

The pitometer force required the use of one of the regular Water Department repair gangs for the work of setting the wooden street "boxes" in position over such supply mains as each district required. These boxes were about four feet on an edge with hinged cover set directly upon the main so as to give access to a standard one-inch corporation cock previously located by means of the regular tapping machine. Through this cock the pitometer enters the main and the flow of water photographically recorded throughout the 24 hours.

These test boxes were often maintained for a week or two in narrow streets with little trouble from heavy traffic. The supply of each pitometer district was continuously recorded for about one week, after which the boxes were removed from the streets to be reset in other parts of the city.

In this way twelve large districts comprising altogether 1,438 acres in Manhattan, and 434 acres in the Bronx were investigated.

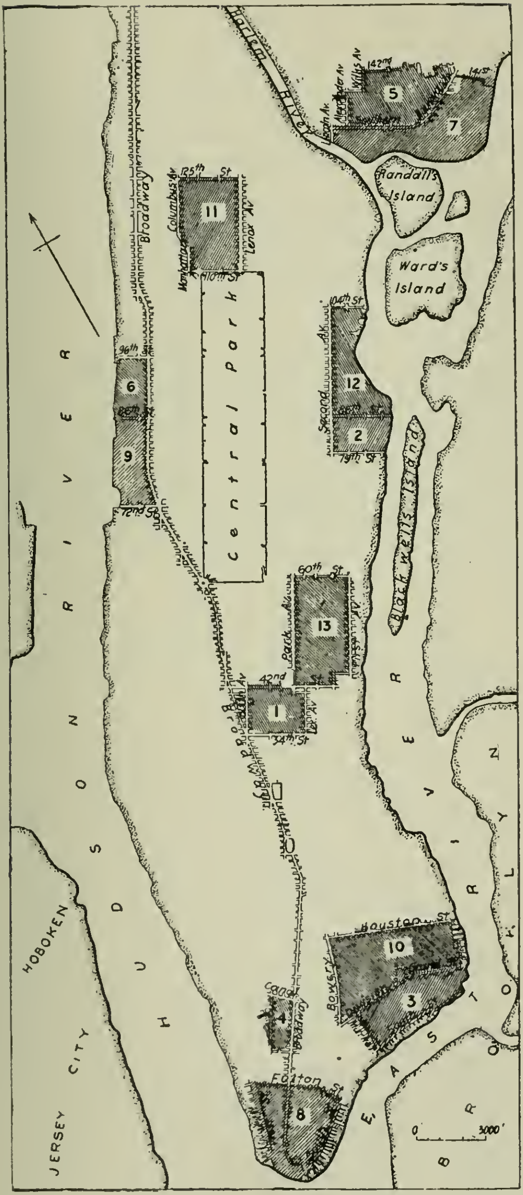
Some of the principal results are shown on the table herewith, in connection with which it is interesting to note that districts Nos. 1, 6 and 9 are high class residental areas. Nos. 2, 3 and 10 are typical tenement house sections, Nos. 5, 11 and 12 contain moderate priced flat buildings, while Nos. 7 and 8 are devoted largely to business and manufacturing.

It is instructive to notice the variation in per capita supply as shown in columns 9 and 10. The effect of transient population in office buildings is well shown in district No. 8, also in district No. 1 which has a comparatively large floating population in hotels and stores.

Perhaps the most interesting results are given in column No. 11 in which appears the gross revenue per 1,000 gallons actually supplied to each district. Here we see a wide variation and singularly enough, the lowest average revenue about 2½ cents and the highest, about 10 cents, are both paid in tenement house districts, Nos. 10 and 2 respectively. A comparison of this showing with the regular meter rate of the department which is 13 1-3 cents per 1,000 gallons, is quite suggestive.

In a recent State report of Mr. Dexter Brackett, C. E., which sets forth the results of metering the supply of various towns in the vicinity of Boston, there is additional proof of a great loss of water even in metered communities. We now have on record many instances where from 30 to 50 per cent. of the total supply is *unaccounted for* in cities, which are nevertheless almost entirely metered.

In district No. 8 of our New York summary it will be seen that, with a supply of nearly ten million gallons daily, the meters account for *only* 50 *per cent!* This district is the office building and business section of lower Manhattan, where meters are supposed to be in very general use. This astonishing state of affairs is unfortunately not uncommon, as has been found by district tests made with the pitometer in several cities. The causes of the discrepancy are undoubtedly the illegal use through unmetered fire connections, or bye-passes, and underground leakage. For these two causes the recent measurements



MAP SHOWING TESTED DISTRICTS IN MANHATTAN AND THE BRONX.

of the total supply in various cities have afforded the strongest evidence.

In assigning these chief causes it is, of course, assumed that the main supply is correctly measured, which, by the way, it often is not, for lack of information regarding "slippage" at the pumps. The ordinary house meter as is well known, is not chargeable with any large part of these great discrepancies, and we are therefore forced to the conclusion that there is much *illegal use* and *underground leakage* in many cities.

Careful attention should be given to the column in our summary showing the amount of visible fixture leakage measured by the house to house inspectors. Considering the poor condition of much of the plumbing in New York, it is remarkable that only 10 per cent. of the total supply was found in leakage. This rate indicates a total fixture leakage for Manhattan and the Bronx of about 44,000,000 gallons daily, an item well worth saving.

SUMMARY OF PITOMETER INVESTIGATIONS, DEPARTMENT OF WATER SUPPLY, CITY OF NEW YORK, 1903.

1 No. of Waste Dist.	2 Total Acres in Borough 100 P. C.	3 Area Waste District. Acres.	P. C.	4 Total Consumption Daily by Pitometer Tests. 100 P. C.	5 Metered Daily. Gallons.	P. C.	6 Leakage in Fixtures. Gallons.	P. C.	7 Population Resident.	8 Total.	9 Gross per Capita Consumption. Res.	10 Total.	11 Total Revenue M Gals. Approx.	12 Total Rev. Met'd & Unmet'd Gallons Yearly.
Borough of Manhattan														
1		127		1,470,000	638,000	43	42,429	3	8,396	12,156	175	121	$.0720	$49,115
2		70		1,440,000	293,000	20	369,000	26	38,906	38,906	37	37	.0988	51,865
3		168		5,400,000	940,000	17	672.500	12	90,000	90,000	60	60	.0498	98,485
6		58		760,000	160,500	21	87,200	11	10,164	10,164	74.8	74.8	.0697	19,300
8		230		9,450,000	5,379,000	56	423,764	5	11,000	114,000	860	83	.0778	269,131
9		75		1,366,000	156,300	11	119,500	9	8,872	8,872	154	154	.0520	25,895
10		310		20,203,000	1,838,000	9.08	1,217,000	6	218,000	218,000	92.7	92.7	.0257	189,763
11		196		4,888,000	364,000	7.4	1.100.000	22.5	43,800	43,800	111.6	111.6	.0539	96,251
12		204		2,750,000	977,000	35.5	697,000	25.2	40,000	40,000	68.5	68.5	.0866	87,019
Total	12,576	1,438	11.4	47,727,000	10,745,800	22.4	4,728,393	9.9	469,138	575,898	101.7	83.2	$0.0566	$886,824
Borough of The Bronx														
5		174		1,730,000	86,000	4.9	329,479	18.8	32.200	32,450	54.3	54	$.0674	$43,023
7		260		1,543,000	776,900	50.4	125,646	8.1	3,076	6,076	502	256	.0742	41,768
Total	26,522	434		3,273,000	862,900	26.2	455,125	13.8	35,276	38,526	93.5	85.6	$.0706	$84,791
Total for Boroughs of Manhattan and The Bronx														
Total	39,089	1,872		51,000,000	11,608,700		5,183,518		504,414	614,424	101.1	83.2	$.0521	$971,615

Estimated Total Plumbing Leakage

Manhattan—4.728,393 gals. is 11.4 per cent. of 41,500,000 gals. per diem, which, at meter rate equals $2,020,000 per annum.
The Bronx—Estimate based on pop. as above, 2,710,000 gals. per diem, which at meter rate equals $132.000 per annum.
Total Estimated Leakage, Man. and The Bronx, 44,210,000 gals. per diem, which, at meter rate equals $2,152,000 per annum.

Mr. Bemis: How do you account for the difference between districts No. 10 and No. 2, both tenement house districts?

Mr. Cole: This discrepancy is strong evidence of abnormal conditions. There must be either a large underground leakage from the mains or an incomplete metering of commercial uses. It is interesting to study the relative gross per capita consumption and the per cent. of metered supply as reported for districts 2, 3 and 10, which resemble one another somewhat in class of population. The hourly variation of consumption as shown by the pitometer records (see the report of New York commission, 1903) gives additional support to the above conclusions. The minimum rate at night being much smaller in district No. 2 than in No. 10.

Mr. T. C. Philips (By letter):

I desire to supply Mr. Cole's paper on Water Waste Investigation with a few items of interest relating to similar work carried on during most of the year 1903 by the Department of Water Supply, Brooklyn.

Our investigations in Brooklyn was preceded by a trunk main survey over the entire system. This consisted of some 85 gaugings throughout the system on 48 inch, 36 inch and 30 inch mains, with pitometer records showing the rate of flow continuously for from four days to one week.

This preliminary work gave the department double results, as it were. It showed the rate of flow at points in the distribution system where previously there existed no information, and from these results important changes in the designs and estimates were made. For instance, several lines of trunk mains were supposed to be carrying too much water, and the low pressure in many districts of the city was attributed to this, when, as a matter of fact shown by the survey, the velocities were rarely over two feet per second at maximum supply.

After completing our trunk main survey, which lasted about eight weeks, a second design and estimate was made for large reinforcement mains in the City of Brooklyn, and the first estimate was cut down from $750,000 to $400,000, or a saving of $350,000 to the city.

Upon the completion of the trunk main survey the waste water investigation was taken up, and eleven districts, ranging from 25 to 300 acres were investigated. These districts were selected partly from the results of the trunk main survey, to ascertain the reason of the abnormal flows into some districts, and partly for the purpose of studying the consumption and waste in typical sections of the city.

Some interesting results were obtained from these investigations; as an example, in some districts the revenue per 1,000 gallons was 8 cents and in others of a like character was about 2½ cents per 1,000. This occurring in districts where the supply was from two to three million gallons per day. In one district, alone consisting of a few blocks of mains, a saving of 2% of the entire consumption of the City of Brooklyn was made, or a saving of 2,000,000 gallons per day.

Although the water pressure in the city ranged from 15 to 40 pounds in the low service districts, the leakage from defective plumbing fixtures was considerable. An estimate of this leakage in the districts surveyed shows a loss of about $40 per annum per acre at the metered rate in the city.

ABOUT COLLECTION OF WATER RATES IN ADVANCE—ALSO LIST OF CITIES COLLECTING FRONTAGE TAX.

By Dow R. Gwinn, President and Manager Terre Haute Water Works Co., Terre Haute, Ind.

There are a number of people who object to paying in advance for a water supply, and the average Water Works man is familiar with such expressions as, "I'll pay for the the water when I get it," "I'm good for my bills," "I don't get my money in advance," and others along the same line.

I have had men swear that they would not pay in advance, at least they swore while making the statement. And then I would get confidential and tell them that we had a plan which would obviate advance payments. That by having a meter set they could pay at the end of each month. That we did not question their financial standing, but that as there are so many people who are not financially responsible that we must collect in advance from them, and in order to treat everyone alike and follow up our system of keeping accounts, it is necessary to ask all to pay in advance if they take water on flat rate basis. The meter proposition usually wins the case.

In order to learn if the custom of collecting in advance is a general one and not confined to private Water Companies, I prepared a circular letter, requesting information in regard to collection of water rates, also about frontage tax, and sent out copies to Water Works Departments and Companies in all cities having a population of at least 15,000.

The information was received several years ago, but in all probability, represents the present method of making collections. Over 200 replies were received, and after leaving out the cities where the meter system is general, the following tabulation was made:

CITY OWNED WATER WORKS.

Bills collected one month in advance	3
“ “ three months “	29
“ “ six “ “	66
“ “ twelve “ “	31
“ “ for calendar year not later than July 1st.	2
Total number collecting in advance	131
Bills not collected in advance	10
Total number reporting	141

Percentage of City Water Works collecting in advance, 92.9%.

PRIVATE OWNED WATER WORKS.

Bills collected one month in advance	3
“ “ three months “	41
“ “ six “ “	19
“ “ twelve “ “	3
Total number collecting in advance	66
Bills not collected in advance	3
Total number reporting	69

Percentage of Private Water Works collecting in advance, 95.6%.

RECAPITULATION.

PUBLIC AND PRIVATE WATER WORKS.

Bills collected in advance	197
Bills not collected in advance	13
Total number reporting	210

Percentage collecting in advance, 93.8%.

It may be well to state that in some States water bills are a lien on the property where the water was used, and can be collected the same as taxes.

Some of the State Courts have held that it is not unreasonable to collect three months in advance for a water supply. At this writing I cannot give references to cases, but would suggest that our members send list of cases that have come to their knowledge, so that the information can be pubished in connection with this paper.

FRONTAGE TAX.

In reference to question, "Do you collect a frontage tax?" the following information was received:

ALLENTOWN, PA.

3″	25c.	per	foot	each	side.
4″	30c.	"	"	"	"
6″	40c.	"	"	"	"
8″	60c.	"	"	"	"
10″	75c.	"	"	"	"
12″	95c.	"	"	"	"
16″	$1.40	"	"	"	"

READING, PA.

Fifty cents per foot front.

SALT LAKE CITY, UTAH.

Cost of extension paid by property according to number of feet abutting property.

CAMDEN, N. J.

Seventy-five cents per foot each side of street. Must be paid before ferrule is driven.

TROY, N. Y.

Twenty cents per foot on all buildings where pipes are laid. Two cents per foot on vacant ground.

NEWBURG, N. Y.

According to frontage.

ROCHESTER, N. Y.

Three cents per foot on all streets where mains are laid, provided water is not taken on any given lot through a service and paid for at the usual rates.

BINGHAMTON, N. Y.

Two cents per foot.

PHILADELPHIA, PA.

One dollar per foot front.

ST. PAUL, MINN.

State Supreme Court declared against collection of frontage tax.

ALTOONA, PA.

Twenty-five cents per foot on each side of street. Nothing for cross street.

AT WHAT RATE CAN WATER BE PROFITABLY SOLD WHEN PUMPED AGAINST A 300-FOOT HEAD?

By W. A. Patton, Catlettsburg, Ky.

When man made his first appearance on earth there were no property rights in existence; at that time everything was on the free list. But man soon began to preempt the earth's surface and then claim title by right of possession, and as he increased in numbers extending his claims until, not only the entire earth's surface was claimed, but he claimed title to all of the mineral within and the animals and structures upon the earth until there were but two objects left on the free list; they being the essentials of life, AIR and WATER; and while those two articles remain on the free list, it must be distinctly understood that the free list only includes them in their natural location and in their undisturbed condition, notwithstanding the adverse opinions that many patrons on the various water lines seem to cling to when they have their water bills to pay.

And while the saying "as free as air" is "proverbial," the fact remains that the most expensive luxury a man can indulge in, if price makes luxury, is the breathing of sufficient air to sustain life under certain circumstances; for instance, the air delivered to laborers working in a caisson, where the contractor, instead of paying them five dollars per day and board, agrees to give them five dollars per hour and air, and the cost of supplying the air is the most expensive part of the job, and if air and water are stricken from the free list we may well ask, in the words of the Maysville poet, "Where on the earth is the place for the moneyless man?"

Our law books say the word "property" is seldom or never used in the law as it is in common conversation, to mean the things which are bought, sold or owned, because in the law it means the ownership of the things and not the things themselves.

In a similar manner, in the sale of water, it may be said that it is not the water that we sell, but it is the service we render. in the delivery of the water, by placing the water under pressure, that we charge for and the quantity of water delivered simply forms the basis on which we make our charges. Therefore, to get at the question as to what is the proper rate a which water should be sold, we must take into consideration all the attending circumstances connected with furnishing the necessary pressure for the supply of the water to the patrons. To get at these facts the cost of running a pump is one of the smallest factors in the calculation. To commence with, we must first take the investment in the plant, and this must not only include the cash contributed in the original construction, but must also include interest on the investment, not only during construction periods before the beginning of the operation, but also must include, not only the interest on the investment during the first few years, prior to the time when the plant is on a paying basis, but should also include such deficits or annual payments as it may be necessary to contribute as an addition to the operating expense to make ends meet at the termination of each year until the incomes are sufficient to meet the interest on the entire investment and operating expenses, and when the cost of the plant is thus obtained we should calculate the annual interest on the same at the prevalent rate in the community in which the plant is located, and add this to the annual operating expenses and then by taking the record of the pump delivery for the year, from which make a due allowance for slippage and a further allowance for leakage in the mains and then divide the remainder into the incomes, an approximate cost of the water delivered can be obtained.

There being but few water plants that can develop sufficient income to pay interest and operating expenses for the first five to ten years. To illustrate what has just been stated let us take a plant, the original construction of which cost $100,000 and the average operating expense of which was $8,000 for the first six years, and that the interest rate is 5 per cent and that it was six years before the plant developed a $13,000 income, which amount would simply pay interest and expenses. In this case the sixth year of its existence would be the only year in which ends would meet, five years being operated at a loss. Supposing the increase in the incomes to be gradual, it would be equivalent to two and one-half years loss at $13,000 per year, or an absolute loss of $32,500, or, in other words, $32,500 more cash had to be invested, by the owners, making the total cash investment $132,500 on which there must be proper interest returns or else the plant will be a bad investment, and in most all cases, and more especially so in municipally owned plants this $32,500 is charged up under the annual operating expenses and passes into oblivion at the end of the year, instead of charging it where it properly belongs, to the construction account and the result is that while there is an absolute cash investment of $132,500 in the plant the construction account only shows $100,000, and on the basis of the construction account all calculations are made and this is the lame place in the calculations that appear in the investigation made by the U. S. Government of public service plants a few years ago.

It cannot be questioned that the $32,500 investment is just as much a portion of the original investment as is the investment in the pumps or pipe line, and if it took a cash investment of $132,500 to get the plant on a basis where the incomes would meet the interest and expenses, then we must calculate on having interest returns on $132,500 in addition to the operating expenses, and if the plant cannot earn that amount it would be better if the promoters had not projected the plant.

In case of private ownership it would be considered as a non-paying investment, and in case of municipal ownership it would have been advisable to have left the money in the hands of the tax payers for their individual investment rather than exacted it from them and then invested it in a non-paying investment. While it is a plain business proposition that no cash should be invested in an enterprise that would not yield proper interest returns, it is a regretable fact that many municipalities totally ignore this principle, and if the receipts from the sale of water are sufficient or nearly sufficient to meet the annual operating expenses, it is considered well enough as it is the tax-payer's money that is invested on which no interest returns are being made, and this is one of the reasons why the price of water service is so demoralized, but there is no reason why this should be the case.

All plants, whether private or municipally owned, should be run on a business basis and the water should be sold at a rate which will yield proper interest returns on the investment.

To obtain a uniform cost for the delivery of water under the thousand of complex complications that are attendant upon the numerous water plants throughout the country is a more difficult matter than a casual observer would take it to be. Some of the factors that may be considered in connection with it are: First—The pumping machinery. If a pump capable of delivering water at a low cost is obtained it will be found that the investment required to obtain such a pump is much greater than to obtain a pump capable of delivering a like amount of water at a higher operating cost. Calculating that the life of the pump is twenty years, and then take the annual interest on the difference on the investment and add to this 1-20 of the difference of the cost and it will be a question as to which is the cheaper pump to operate. Secondly—The height to which water is lifted. It being a conceded fact on the part of hydraulic engineers that it cost approximately twice as much to lift water 200 feet as it does 100 feet, and in the smaller cities where fire engines are not used, it is necessary to pump the water against sufficient pressure to get the needed protection, thus adding to the cost, and in most of our Kentucky cases the cities are built on the streams which have high banks, thus necessitating a larger lift to obtain the zero point at the street level and to obtain a pressure it must have the additional lift. The banks of the Ohio River, above Covington, Ky., having 70 feet of a difference between high and low water, necessitates pumping water against a 300-foot head to get 230 feet above the city. The other important factor is the cost of fuel, the purification of the water and the investment in the plant and the class of consumers to which the water is delivered. Under the complex conditions it is a difficult matter to arrive at a uniform cost, and in many single plants the conditions are so complex that it would require an added expense greater than most small plants desire to bear to keep the necessary data for calculating the cost. In the journal of the New England Water Works Association of September, 1902, will be found a very complete table in which is all of the data connected with the operation of many plants. In this list there are forty cities in thirteen States, but only twenty-two of them are sufficiently complete to show the cost of delivering the water to the patrons. In the list of twenty-two cities, excepting Brockton, Mass., which only pumps against a head of 38 feet, there are but five cities which pump against a head less than 158 feet, they being Plymouth, Mass., 65 feet; Taunton, Mass., 67½ feet; Oberlin, O., 80 feet; Atlantic City, N. J., 93 feet, and Bay City, Mich., 113 feet; while there are eight of the list that pump against a head of over 210, the highest being 289 feet, as shown in the table at Burlington, Vt. The average cost of the water delivered to the reservoir where pumped against the various heads in these twenty-two cities is 10.95 cents per 1.000 gallons. Estimating that it would cost a proportional amount in each case to deliver the same to a height of 300 feet where pumped, we find that the average cost of water thus delivered would be 19.94 cents per 1.000 gallons.

In making an analysis of this list we find that among the lowest cost given for water is at Bay City, Mich., a city of 20,000 population, where they pump the water against a head of 113 feet at a cost of 3¼ cents per 1,000 gallons, equivalent to 8.57 cents if pumped 2 7-10 times as high, or 300 feet, but we find that the Bay City plant cost $607,461.62, and in the calculation they only estimate interest on their bonded indebtedness, which is $352.000, thus leaving an investment of $255,461.62 on which no interest is calculated. Should we add annual interest on that amount to the expense account we find that it would add 1¼ cents to the thousand gallons of water pumped, thereby making the water pumped against their head 4.67 cents, which is equivalent to 12.35 cents per thousand gallons if pumped against a 300-foot head. At Cambridge, Mass., we find that they pump against a head of 158 feet for 2.84 cents per thousand gallons, but Cambridge is a city of 90,000 population, up in New England, where they obtain interest at 3¾%, and that rate precludes comparison with any plant in this section, and furthermore they have an investment of $141.586.69 on which they are paying no interest. At Woburn, Mass., a city of 14,250 people, water is pumped against a head of 200 feet at a cost of 2.72 cents per thousand gallons, but Woburn has an investment of $597.697.56 on which they only have $97.650 of 4% bonds, leaving $500,047.56 of an investment on which no interest is calculated. They pump 426.638.100 gallons of water per year; if we add annual interest on the investment on which no interest is calculated, it will add 7 cents per thousand gallons to the cost of the water, making it 9.72 cents per thousand gallons pumped at their plant against their head, or 11.08 cents per thousand gallons if pumped against 300-foot head.

The only other place on the list where the cost of water is below five cents is Waltham, Mass., where they have only about three-quarters of the cost of the plant bonded and get a 4% rate of interest, and at this rate the water costs 4.98 cents pumped against a head of 164 feet.

The highest cost in the list is at Billerica, Mass., where the water costs 27.3 cents per thousand gallons pumped against 275-foot head, or at Brockton, Mass., where it costs 10.7 cents per thousand pumped against 38-foot head. At Burlington, Vt., it costs 11.9 cents per thousand gallons pumped against 289-foot head, and Freeport, Me., it costs 13 cents per thousand gallons against 160-foot head.

THE LOWER ROXBOROUGH PRELIMINARY FILTERS.

BY P. A. MAIGNEN, PHILADELPHIA, PA.

In New York in 1901, and Chicago in 1902, the author had the pleasure of addressing the members of this association on some new ideas concerning the preliminary treatment or scrubbing of water previous to its admission to slow sand filters. It may not be without interest, at this time, to report some practical progress made in this line of water purification in the City of Philadelphia.

The Lower Roxborough Preliminary Filters, which form a part of the general filtration system of the City of Philadelphia, John W. Hill, Chief Engineer, and have been designed and installed by the author, and have now been at work for upwards of six months. The Schuylkill River has been, during most of this time, generally in a very bad state both as regards turbidity and bacteria, and it has afforded a good opportunity for testing the system thoroughly.

A description of this installation, together with a statement of the results obtained, and some few observations on filtration in general and preliminary filtration or scrubbing in particular may prove of some interest to many of our members.

DESCRIPTION OF THE LOWER ROXBOROUGH PRELIMINARY FILTERS OR SCRUBBERS.

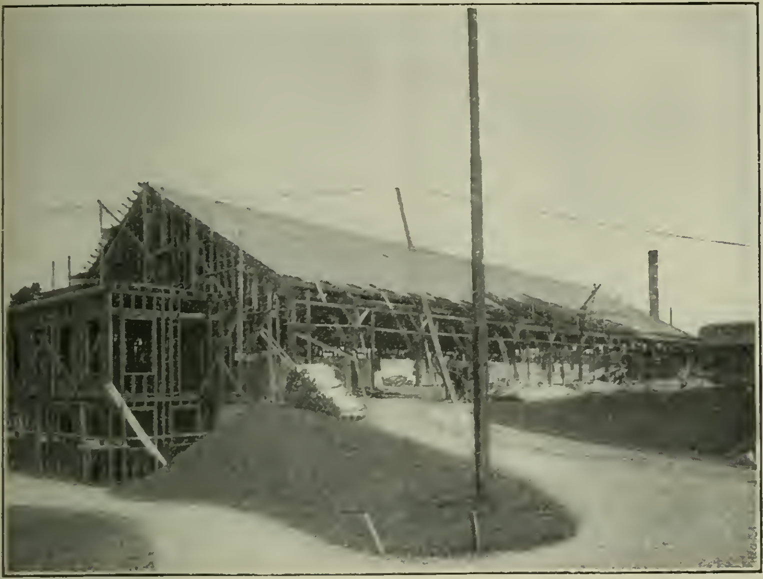
The plant was designed for scrubbing 12,000,000 gallons of water daily. Fig. 1 shows the outside appearance of the scrubber building. On the right, in the distance, is the auxiliary or high level pumping station; on the extreme right the slope of the sedimentation basin, and in front part of the court with some heaps of sand intended for use in the slow sand filters, which are on the right, but are not seen.

EMBANKMENT.

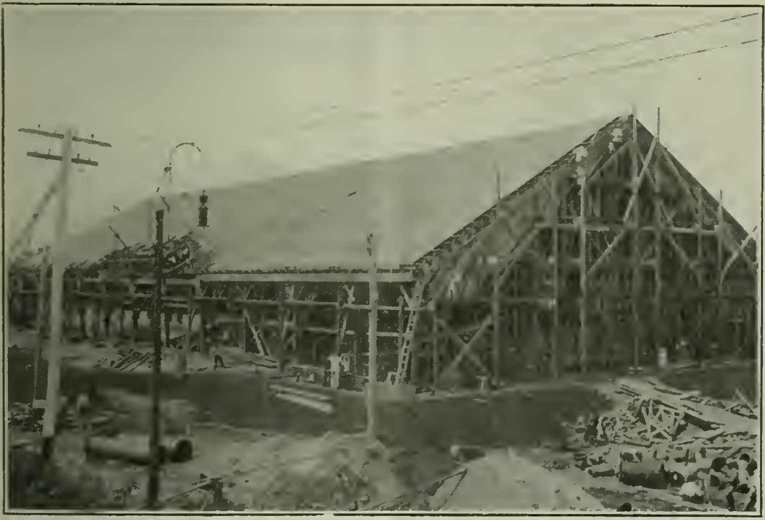
The water goes, by gravity, from the settling reservoir to the preliminary filters, and from the preliminary filters (by gravity also) to the final slow sand filters. The topography of the ground available for the preliminary filters was such as to necessitate an embankment of earth averaging 12 feet in height, with a retaining wall at the lower end, as shown in Fig. 2 and Fig. 3.

NO. 1—THE LOWER ROXBOROUGH PRELIMINARY FILTER HOUSE.

The surrounding micaceous soil was used and rolled in layers of 6 inches with a 10-ton steam roller. Twelve inches of puddle were placed all over the surface. The embankment was made with such care that it was considered perfectly safe to start building the concrete tanks as soon as the puddle was laid down, so that no serious



NO. 2—THE LOWER ROXBOROUGH PRELIMINARY FILTER HOUSE.
General View During Construction, Embankment Shown—West End.



NO. 3—THE LOWER ROXBOROUGH PRELIMINARY FILTER HOUSE.
General View During Construction—East End.

trouble was expected from settlement of the ground; as a matter of fact, no settlement of any appreciable degree occurred. What settlement did occur, being general all over the embankment, had no effect upon the stability of the concrete construction, which is shown in Figs. 4 and 5, the former being the inlet or influent side and the latter the outlet or effluent side.

CONCRETE.

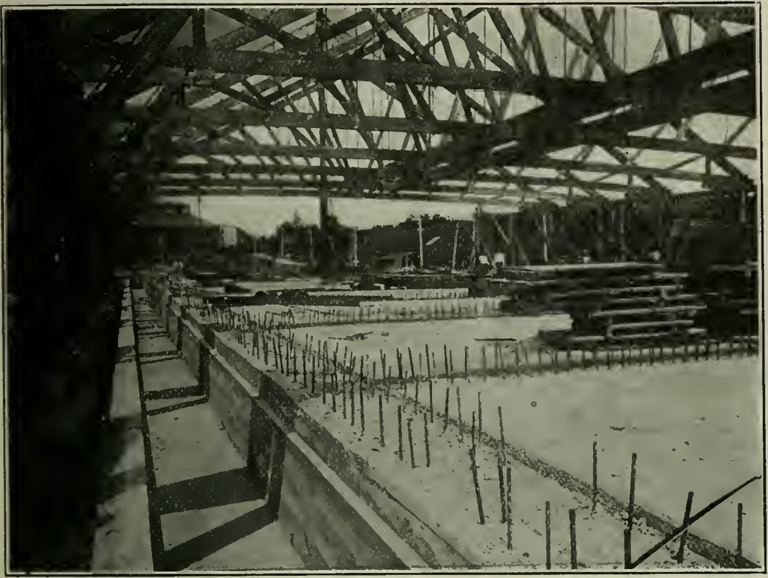
The floor and the walls are made of plain concrete, with the exception of the base of the wall, which has been anchored in the floor by means of half-inch square iron rods, 18 inches long, placed vertically every 12 inches, and also some 1-inch square rods, 4 feet 6 inches long, laid horizontally every 6 inches center (in that part of the floor which serves as a base for the walls).

The division walls are 15 inches at the top and 24 inches at the bottom; the outer walls are also 15 inches at the top, but 30 inches at the base. The total height of the tank is 6 feet. The floor itself is dished, as shown in Fig. 6, being 14 inches thick against the wall and 6 inches in the center. Bolts, 1 inch in diameter, are inserted in the walls to secure in place the "I" beams, which are also shown in Fig. 6 and are intended to resist the upward thrust of the elastic layer. There are, altogether, eleven tanks, 16 feet wide, 64 feet long, which give 1,024 square feet of filtering area for each tank, or 11,264 square feet for the eleven tanks.

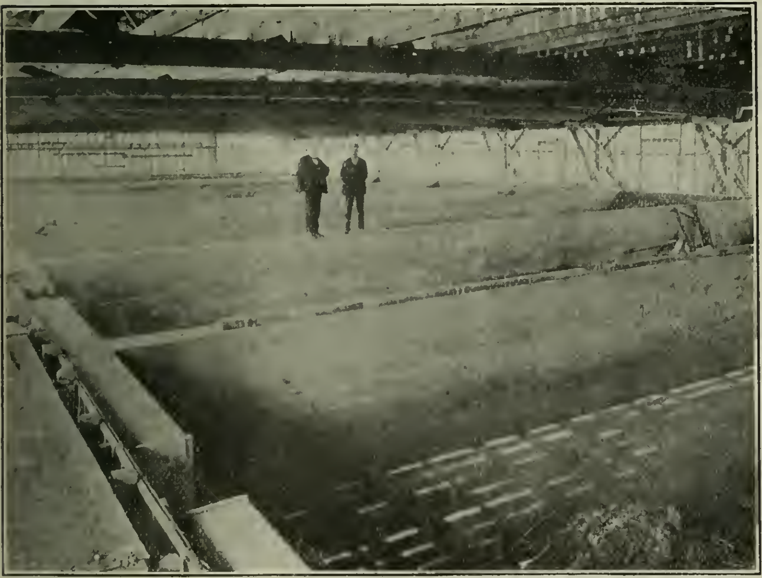
RATE OF FILTRATION.

When all the units are at work the rate of filtration is 0.74 gallons per square foot per minute, or 1,065 gallons per square foot per day, or 46,417,436 gallons per acre per day.

When one filter is out of service, and if the full 12 million gallons are wanted, the rate of filtration is in-



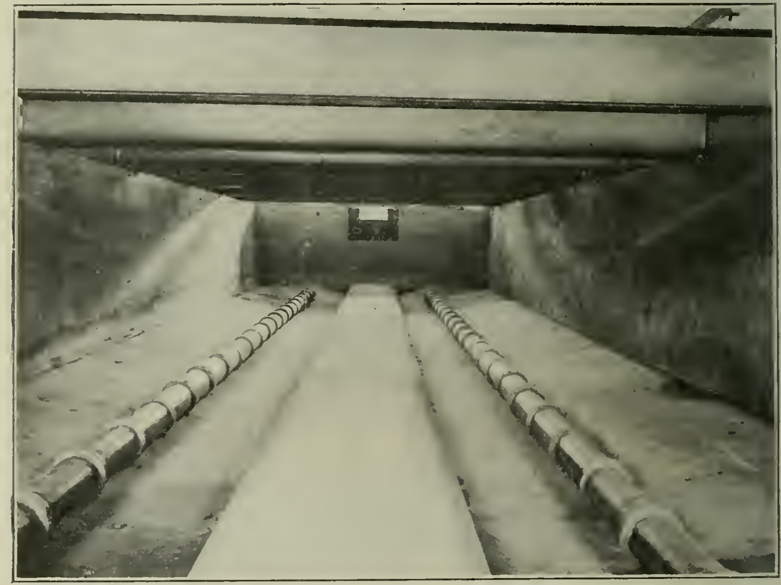
NO. 4—THE LOWER ROXBOROUGH PRELIMINARY FILTERS.
General View Showing Steel Reinforcements for the Walls.



NO. 5—THE LOWER ROXBOROUGH PRELIMINARY FILTERS.
General View Showing Division Walls.

creased to 0.81 gallons per square foot per minute, or 1,164 gallons per square foot per day, or 50,808,384 gallons per acre per day.

The latter rate is by no means excessive; in fact, the filters may be rated at 60 million gallons per acre per day, which is equivalent to .956 gallons per square foot per minute.



NO. 6—THE LOWER ROXBOROUGH PRELIMINARY FILTERS.

View Showing Supply Pipes, Drain and Weir for Measuring the Scrubbed Water.

If the eleven filters were at work at this rate they would give: Eleven filters x 1,024 sq. ft. x .956 gals. x 60 minutes x 24 hours = 15,506,467 gallons.

SEDIMENTATION.

The water of the Lower Roxborough Filter Station is pumped from the Schuylkill at the Shawmont Pumping Station. It passes through a reservoir containing about 12 million gallons, which is equivalent to twenty-four hours' supply.

FILTERING MATERIAL AND DIRECTION OF FLOW.

In the Lower Roxborough Preliminary Filters or Scrubbers the water enters at the bottom and rises upwards through a 41-inch layer of material—furnace slag—varying in size from 3 inches to 1 inch, and through 14 inches of sponge, which constitute what is known as an elastic layer. The sponge is held down in place by cedar slats; these are prevented from floating up by yellow pine stringers and blocks, wedged under the steel "I" beams already alluded to.

SPONGE WASHING MACHINERY.

Fig. 7 shows the sponge being replaced in the bed after cleaning.

Fig. 8 shows the Sponge Washing Machinery, which is driven by an electric motor. The man in front takes the clean sponge out of the machine. The man bending down is taking up the dirty sponge from the ground, where it has been spilled, and placing it in one of the washers. The foreman, in the rear, attends to the valves and motor.

RESULTS.

The Preliminary Filters or Scrubbers have had one first run averaging six months. The individual preliminary filter or scrubber units have generally been working at the normal rate of flow, which is equal to 48 million gallons per acre per day. When less than 12 million gallons are wanted some of the units are lowered to a very slow rate, the majority being maintained as much as possible at the normal rate. Most of the time the quantity filtered has varied from 9 to 11 million gallons for the whole plant. Sometimes it has been as low as

NO. 7—THE LOWER ROXBOROUGH PRELIMINARY FILTERS.
Replacing the Sponge In the Bed After Cleaning.

NO. 8—THE LOWER ROXBOROUGH PRELIMINARY FILTERS.
Spray Washing Machinery In Operating.

6 million gallons, because the pumps could not give more or the consumers did not require the water. Sometimes also it has been necessary to force up the rate of some of the units to 60, 80 and even 90 million gallons per acre per day in order to meet a sudden demand for filtered water. These variations in the rate of filtration are usually very obnoxious, so that great care is taken to have devices for regulating the flow in and out of the filters. With the Lower Roxborough Scrubbers no disturbances of any kind has been noted. The sudden change from the lowest rate to the highest has not brought about any appreciable change in the quality of the effluent. In designing scrubbers, however, it is considered advisable to count upon a minimum rate of 48 million gallons and a maximum rate of 60 million gallons per acre per day.

The daily turbidity readings and bacteria counts have been as shown in diagrams herewith:

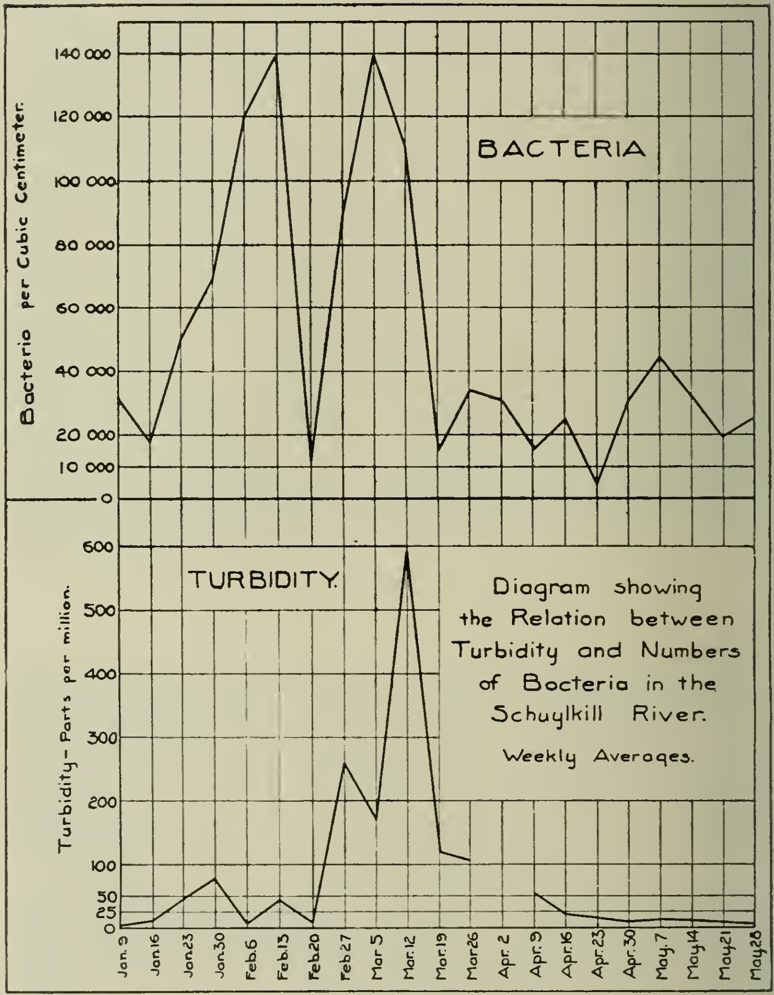


Diagram showing the Relation between Turbidity and Numbers of Bacteria in the Schuylkill River.

Weekly Averages.

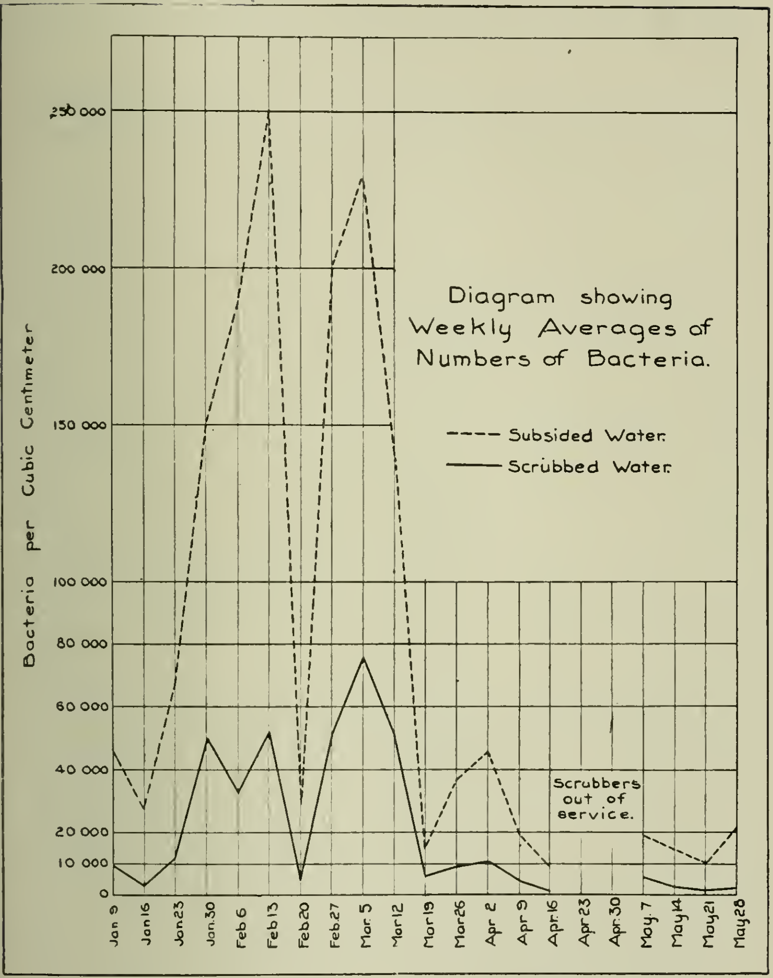
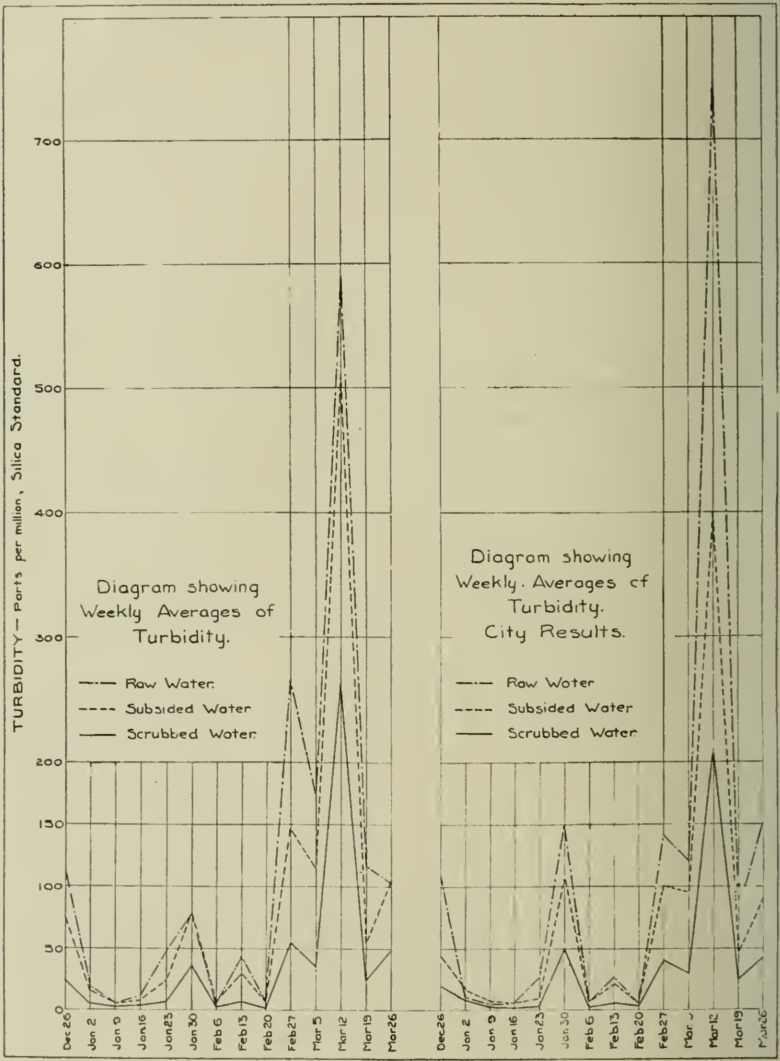


Diagram showing Weekly Averages of Numbers of Bacteria.
---- Subsided Water.
—— Scrubbed Water.
Scrubbers out of service.
Bacteria per Cubic Centimeter
250 000
200 000
150 000
100 000
80 000
60 000
40 000
20 000
10 000
0
Jan 9
Jan 16
Jan 23
Jan 30
Feb 6
Feb 13
Feb 20
Feb 27
Mar 5
Mar 12
Mar 19
Mar 26
Apr 2
Apr 9
Apr 16
Apr 23
Apr 30
May 7
May 14
May 21
May 28


TURBIDITY — Parts per million, Silica Standard.
700
600
500
400
300
200
150
100
50
0
Diagram showing Weekly Averages of Turbidity.
Raw Water.
Subsided Water
Scrubbed Water.
Diagram showing Weekly. Averages of Turbidity. City Results.
Raw Water
Subsided Water
Scrubbed Water.
Dec 26
Jan 2
Jan 9
Jan 16
Jan 23
Jan 30
Feb 6
Feb 13
Feb 20
Feb 27
Mar 5
Mar 12
Mar 19
Mar 26

It is believed that when the yearly average is made up the theoretical 65 per cent. removal of turbidity and 80 per cent. of bacteria removal will be fully attained, because the last six months have included the worst period of the year, and the next six months will include the best part of the year; also because the sponge layer has been laid, after washing, with much more care than when at first put in the beds.

FINANCIAL ADVANTAGE OF SCRUBBING.

The importance of subjecting the water to a preliminary scrubbing before final filtration through slow sand filters can be appreciated financially as follows:

If 65 per cent. of the mud is removed by the preliminary process, which costs 75 cents per million gallons (for operation), and if the 35 per cent. left are removed by the slow sand filters (the operation of which costs $4.00 per million gallons) we shall have as a total cost for operation by the double system of

65 per cent. x 75 cents	$0.48
35 per cent. x $4.00	1.40
Per million gallons, filtered	$1.88

If, to the cost of operation, we add the fixed charges or interest and depreciation at 5 per cent. on the average cost of installation ($7,000 per million gallons capacity) we shall have a total cost of

Operating charges	$0.75
Fixed charges	.96
Total, per million gallons of water scrubbed	$1.71

The cost of plain slow sand filters, according to the most recent estimates, is $125.000 per acre. The rate of filtration is estimated at Washington and Pittsburg at 2.220,000 gallons per acre per day. This will give $7.30 per million gallons filtered for interest and depreciation at 5 per cent. per annum. The cost of filtering the water by plain slow sand filters alone would therefore amount to

Operation	$4.00
Interest and depreciation	7.30
Per million gallons of water, filtered	$11.30

If we compare the relative cost of removing all the mud by means of the double process of scrubbing and filtering with the total cost of filtering by the plain slow sand filters alone we shall have the following:

65 per cent. of the work done at $1.71	$1.11
35 per cent. of the work done at $11.30	3.95
Per million gallons of water double filtered	$5.06

This cost, compared with that of filtering by slow sand filters alone, produces a saving of $6.14 per million gallons of water purified. This, applied to filter plants of different capacities, will give the following results:

Million gallons per day.	Saving per mil. gals.	Days.	Annual Saving.	Capital represented by this saving at 4 per cent.
20	$6.14	365	= $44,822.00	$1,120,550.00
60	6.14	365	= 135,466.00	3,386,650.00
80	6.14	365	= 179,288.00	4,482,000.00
100	6.14	365	= 224,110.00	5,602,750.00
150	6.14	365	= 366,165.00	8,404,125.00
200	6.14	365	= 448,220.00	11,105,500.00
300	6.14	365	= 672,330.00	16,708,250.00
400	6.14	365	= 896,440.00	22,311,000.00

A FEW OBSERVATIONS ON FILTRATION IN GENERAL AND SRCUBBING IN PARTICULAR.

Water Works Engineers, notwithstanding their yearly pilgrimage to the Convention of the Association, where they meet and discuss with filtration experts, notwithstanding their knowledge of all the books and reports on filtration during the last few years, must, at the present moment, be very much embarrassed when they are requested to submit to the administration which they serve (municipal or corporate) a recommendation for filtering the water. The wise generally answer, "I do not know; let us experiment; let us engage the services of the best-known experts in the country and find out which system will best suit our particular water." The unwise may be led by that "little knowledge" spoken of by the poet, "which is a dangerous thing" to declare that because plain, slow sand filters have been more or less successful abroad this is the system to adopt for the particular works under consideration. Or he may argue concerning mechanical filters thus: "I have visited some mechanical or so-called 'American' filter plants in which alum is used. The water is bright, the first cost is less than that of slow sand filters; it is an American invention, used in many cities; let us adopt it."

The administration to whom these reports are made might point out many cases of failure.

The failure in both the slow sand filters and the mechanical filters does not prove that both systems are absolutely bad in themselves. It does prove, however, that they are, at times, insufficient. It also proves that too much has generally been asked from them.

A filter is not like a flywheel that turns round and round without any appreciable wear and tear or labor other than oiling the shaft. Filters have a life of their own. When absolutely new they do not give satisfactory results, because the filtering materials are not "seasoned" or "ripened" or "settled." When, after some months' work, they are "ripe" they perform their work of collecting the impurities of water, generally, in a satisfactory manner for a time, but they have no digestive organs or eliminating organs working automatically as in the case of animal life; they therefore gradually become clogged and cease to work. Something must be done to remove the clogged material; they must be cleaned. How to do this economically and restore life to them is the problem upon which filtration experts are working at present. They have also to find out what is the best size and quantity of materials and how to use them best for the filtration of each particular class of water; they have to decide whether chemicals should or should not be used, and, if necessary, their nature, proportion and manner of use. They have to also study and advise in a general way on all matters pertaining to the improvement of the water supply, not only quantitatively and qualitatively, but also financially.

That neither the "plain slow sand filters" nor the "mechanical" or "American" filters have proved altogether successful can be gathered from the following statement made by one of the best experts on the art of filtration in this country, and whom you all know, Mr. George W. Fuller. (Transactions of American Society of Civil Engineers, June, 1903):

"While, as is well known, in the majority of cases mechanical filters have not been operated in a manner to produce uniformly good results, it is a fact, which does not seem to be appreciated by many, that the majority of the larger (slow) sand filters in this country that have been operated for several years have also failed to reach the goal which may be expected of them, as is noted by any one who takes the trouble to examine carefully the typhoid fever experiences in cities which have (slow) sand filters, such as Poughkeepsie, Hudson and Little Falls, N. Y.; Ashland, Wis., and Rock Island, Ill., etc."

It has been usual lately to speak of the rate of filtration of slow sand filters as of 3 million gallons per acre per day, but the simplest investigation will show that there is no evidence of any such rate having been maintained in practice for any length of time with river waters. According to Mr. Allen Hazen (Filtration of Public Water Supply), the Hamburg filters "were intended to filter at the rate of 1.60 million gallons of water daily and were not allowed to filter faster."

In London in 1868 the rate was 2.28 million gallons of water per day. In 1885 it was reduced to 1.61 million gallons of water per day. In 1898, according to Mr. John W. Hill (Filtration of Public Water Supply), the average London rate was 1,800,000 gallons per acre per day, and at York, which is supposed to have the most approved and one of the oldest water works system in England and where the water is twice filtered, the rate of filtration is only 1,140,000 gallons per acre per day. At Breslau, Altona and Frankfurt the rate is 1.85 million gallons, and the yield between scrapings is 55 million gallons. At Bremen, Koningsberg, Brunswick and Posen the rate is 1.34 million gallons per acre daily, and the yield between scrapings, 40 million gallons per acre. According to Colonel A. M. Miller, "the average rate of filtration of the English system is 1,700,000 gallons per diem per acre." The last estimates made for slow sand filters, those of Washington and Pittsburg, are based upon a rate of 2,220,000 gallons a day, on the assumption that all the filters are at work and none out of service for cleaning. There seems, therefore, to be some reason to fear that this rate will not be maintained with satisfactory results for any length of time unless something is done in the way of preliminary treatment of the water to facilitate the work of the sand beds.

In their report made on February 27, 1904, to the Finance Committee of City Councils of Pittsburg, the three experts, Messrs. John W. Hill, Rudolph Hering and Colonel A. M. Miller, say:

"At Philadelphia preliminary filtration is a fundamental part of the present works, the chief object of which has been to reduce the area of filters required by permitting of an increase in the rate of filtration per unit of sand surface.

"Three objects are sought to be obtained by preliminary filtration of the water before it is passed to the filters:

"1. An increase in the rate of filtration per acre.

"2. A prolonged (working) period of the filter with a corresponding reduced cost for maintenance.

"3. A better control of the water applied to the (final) filters with the varying conditions of the raw river water."

There is one fourth object worthy of consideration in favor of preliminary filtration, and it is this: When the sand is quite new it is composed of grains of various sizes all the way from what is retained on a No. 60 sieve to what passes through a No. 10 sieve. These different sized particles lay together close and combine to make a very perfect filter, particularly after a few months' use. Each time the sand is taken out of the filters for washing there is a certain loss of the finer particles and a stratification of the coarser grades. As the washing operations increase in number this elimination of the fine particles and stratification of the coarser ones goes on increasing until the sand bed is little more than a skeleton of its former self. This evidently explains why, in various experiments made with plain slow sand filters during a few months or even during one whole year, it has been found possible to get as much as 3 or even 4 million gallons of water per acre per day without any preliminary treatment of the water, but it would not be safe to count upon maintaining such rates with average river waters after the sand has been washed a certain number of times.

A device, therefore, that will reduce the number of cleaning operations of the sand and maintain its effective qualities will not only insure good rates of filtration but also prolong the natural life of the sand. For instance, if the sand has to be cleaned every time 30, 50 or 60 million gallons have been filtered it stands to reason that it will sooner be used up than if the "runs" reach 180 million gallons per acre and at the same time the per million gallon cost of sand renewal will be very much reduced.

An exhaustive inquiry was made in 1901 and 1902 by Messrs. Rudolph Hering and George W. Fuller, members of this association, into the practicability of the Preliminary Filters or Scrubbers now under consideration to help solve, economically, the problem of purifying the Philadelphia water supply by the slow sand system. A report entitled "Report on the Investigations made at Philadelphia into the Maignen System of Water Purification for Municipal Supplies," by Rudolph Hering and George W. Fuller, May 3, 1902, was made upon the scrubbers of the Arch Street Experimental Station and those of the City Testing Station at Spring Garden; the following extracts at this juncture may not be without interest:

"Does a scrubber allow a final filter to be operated at a higher rate than when the preparatory treatment is obtained by settling basins alone?"

"Regarding the relative fitness for final filtration of a settled water (for, say, one to three days) and a scrubber effluent, it is to be remembered that the greater clearness of the latter is not the only difference. The scrubber effluent is purer from a bacterial standpoint, as the percentage removal of bacteria in the river water by sedimentation and by scrubbing is about 40 and 80, respectively, on an average. Thus the purity of the scrubber effluent would be three times as great as that of the settled water." . . . (20 per cent. of the bacteria are left in the water from the scrubber as compared with

60 per cent. left in the water from the settling basin).

"In a number of places it has been found that when a water has been filtered once, under ordinary conditions as to rate and materials of filtration, a second filtration is sometimes of very little or no benefit."

"The reason assigned for this experience is that the first filtration removes those constituents which are necessary to 'ripen' a filter through the establishment of gelatinous films around the sand grains and of certain biological processes. This aspect of the matter has received very careful attention, and the evidence shows that excellent results may be regularly obtained from the filtration of the Philadelphia water after it has passed through a scrubber. The construction of the latter and its rate of filtration do not seem to impoverish the local water prejudicially as to those constituents needful for developing and maintaining the final filter in a well-ripened and efficient condition."

"Having ascertained that the scrubber effluent in no way lessens the efficiency of final filtration, the question can now be taken up as to whether it allows the final step in the complete process of purification to be carried on at a higher rate than in the case of settled water. The evidence at hand indicates that this is so, and, should there arise any disturbing factors, the effect of such would be less marked with a scrubber effluent, which, of itself, represents a substantial purification of the river water. In short, the application of a scrubber effluent of the character noted would insure a greater degree of stability to the final filters, other conditions being the same."

"From the above statement it logically follows that with a scrubber effluent the same degree of stability would be obtained at a higher rate of filtration than in the case of settled water. In practice we certainly believe that this would be true."

"Does a scrubber prepare the raw water so as to allow the final filter to be operated more cheaply than when settling basins are used?"

"Experience shows that as a general proposition the cost of operating large filter plants of the type under consideration is proportional to the amount of clogged material removed per unit volume of water treated."

"This statement assumes, of course, comparable conditions as to facilities and wages of laborers, and disregards such special features as removal of ice from open filters. The cost of executive and laboratory control is also excluded, as this is not directly related to the character of the water after it has been prepared for final filtration."

"Experience at several places show that, approximately speaking, the amount of clogged material to be removed from filters, other things being equal, is proportional to the turbidity (within ordinary limits) of the applied water."

"When raw water is applied to filters, complications arise in some instances from algae growth and suspended organic (amorphous) matter, which clogs a filter to an excessive degree in proportion to its turbidity. Notwithstanding the obscuring of data by a variety of causes in practice, this principle is a correct one."

"From the foregoing it follows that the cost of filter operation is approximately proportional to the turbidity of the applied water, and upon this principle rests one of the principal merits of the scrubber."

"Available evidence indicates that settled water at Philadelphia would average about 20 parts of turbidity. With filters operated at a 6 million gallon rate and a 4-foot loss of head, the yield between cleanings would probably average about 70 million gallons per acre, and the average depth of scraping about three-fourths of an inch.

This makes the amount of clogged material to be handled about 1.5 cubic yards per million gallons of water filtered."

"As to the average turbidity of a scrubber effluent it would probably be between 5 and 10 parts. We consider that there is every reason to believe that the average filter yield between cleanings would be about twice as great as with settled water, other things being equal."

"Hence it is concluded that a scrubber effluent, as compared with settled water, would reduce the cost of filter operation by about 50 per cent."

"How does the cost of preparing the local river water by settling basins and by scrubbers compare?"

"From the evidence presented up to this time it is to be gathered that a scrubber could give additional stability to a system of purification in which a high rate of filtration is employed; it is entitled to certain financial credit by making feasible those relatively high rates of filtration; and it could reduce by about 50 per cent. the cost of filter operation."

"PREPARATION FOR FILTRATION OF PHILADELPHIA RIVER WATER IN SETTLING BASINS."

"When water approaches quiescence the matters in it are, to a greater or lesser degree, deposited. The rate of deposition depends upon the remaining velocity of the water in connection with the subsiding value of the suspended particles. Velocities are affected by relative temperatures of water and air, and by the degree of baffling which exists in a basin to prevent water from passing from the inlet to outlet, and thus putting a portion of the basins out of service, practically speaking."

"It is customary in practice to refer to the degree of settling as the period corresponding to the duration of flow required in order to fill the basin, such a period is hardly obtained as a matter of fact, as much of the water passes out in less than this time."

"General experience indicates that, as a rule, it is not economical or advisable to continue plain sedimentation in water purification works to more than about 24 hours. Exceptions, of course, are to be found where this factor has to be considered with reference to other portions of some works."

"PREPARATION FOR FILTRATION OF PHILADELPHIA RIVER WATERS WITH SCRUBBERS."

"Regarding the best kind of elastic layer to use, it has been found that sponge clippings are somewhat more efficient than peaty fibre. So far as can be ascertained, there is available a sufficient quantity of sponge clippings to serve all needs in view. Should prices become excessive for this commodity, peat or similar material might be substituted temporarily."

"As to the life of sponge clippings in a 'scrubber,' there is no evidence of chemical decomposition, owing to the mineral nature of the product."

"As a scrubber, as well as settling basins, would be operated in connection with filters, it is unnecessary to make any extra charge for watchman or for executive or laboratory supervision. The valves would need regulating at only infrequent intervals, and ordinarily could be attended to by the men engaged in cleaning the device."

"COMPARISON OF EFFICIENCY AND COST OF PREPARATORY TREATMENT OF SETTLING BASINS AND SCRUBBERS."

"The available evidence indicates that the average removal of turbidity from the local river waters by settling basins (24 hours' capacity) and scrubbers would approximate about 30 and 65 respectively."

"Regarding bacteria, these percentages are estimated at 40 and 80 respectively."

"As to the residual turbidity of the treated water during all ordinary conditions of the river, it is estimated that it would be about 20 and 10 parts respectively. The probabilities are that a scrubber effluent is much more likely to average less than 10 parts than is a settling basin less than 20 parts."

The following are some of the conclusions of the report from which we have just made extracts:

"The practicability of the higher rate through the sand layer (6 million gallons per acre per day) of the final filter in the Maignen system is accounted for by the better preparation of the water for filtration. This preparation of the water is accomplished chiefly by the scrubbers."

"Scrubbers, as compared with settling basins, make higher rates of filtration feasible in the final filters, perhaps double, according to the prevailing practice, and therefore effect in the latter a decided reduction in the cost of filter construction."

"Where reservoirs already exist, scrubbers will reduce the cost of operating the final filters sufficiently to save their own total cost in addition to the saving effected by the smaller area of the filters."

"Where reservoirs are not yet built, scrubbers will effect a saving of .... per million gallons of water purified, in addition to the saving effected by the smaller area of the filter."

The conclusions of the experts above cited have been fully confirmed in every particular by the actual working of the Lower Roxborough Preliminary Filters or Scrubbers. These have allowed the City of Philadelphia to obtain from the Lower Roxborough plain slow sand filters a rate of filtration double that of the plain slow sand filters of Upper Roxborough, where the water is settled in sedimentation basins, holding at least thirteen days' supply. The bacterial and physical results are absolutely as good from the Lower Roxborough as from the Upper Roxborough Filters, and the cleaning operations are not anything like as frequent.

Much more could be said in favor of Preliminary Filtration, not only as applied to slow sand filters, but also to mechanical filters; but the author thinks that what precedes will be sufficient to interest the members of the association and raise a useful discussion.

THAWING SERVICES AND MAINS BY ELECTRICITY.

J. M. Diven, Secretary.

The process of thawing water services and mains by electricity was very ably and grahpically described in Mr. Heim's paper, read at the nineteenth annual convention of this association, 1899, in which he fully described the process used by Professors Jackson and Wood in thawing services at Madison, Wis. And the description herewith is not given as anything new, but to perpetuate the knowledge of the work done then, and for the benefit of the newer members who did not receive copies of the proceedings of that year.

The extreme severity of the past Winter gave much trouble from freezing services, and Mr. H. M. Beugler, manager of the Electric Light Department, proposed the use of electricity for thawing them. He did not know of the Madison work, but got up an outfit almost identical with that used there.

The apparatus consisted of:

First—A 50 k. w. transformer, the primary current here being 2,000 volts.

Second—A barrel of water, containing sufficient salt to decrease resistance.

In this barrel were two pieces of metal, with sufficient contact surface to carry the required amount of current; he used two old cylinder heads, which nearly equalled the sectional area of the barrel. To the bottom one of these pieces of metal a secondary wire from the transformer was attached, and one of the same size was run from the other to some fixture on the frozen service. The upper piece was arranged so that it could be raised or lowered in the barrel to regulate the quantity of current.

Third—An ammeter, and

Fourth—Plenty of insulated wire; No. 8 for the primary and No. 0 for the secondary.

For convenience this was all mounted on a wagon; though at first a rheostat was used instead of the barrel of water for regulating the current. One man from the Water Department, to locate the services and fixtures; two linemen to make connection to the electric light wires and one man to tend to the current were required to operate the apparatus.

OPERATION.

The transformer was first connected with the 2,000-volt primary-alternating current light or power line—using two lines of the No. 8 wire. Then one secondary—No. 0—wire was carried to the nearest fire hydrant, gate valve or operative service connected to the main, as near as possible to the service to be operated upon; the other secondary being attached to the bottom piece of iron in the barrel. A similar wire—No. 0—was then run from the upper iron in the barrel to a faucet or some other convenient connection on the frozen service, beyond the point where it was frozen. The current was then turned on, and, with the upper piece of metal in the barrel, was, by raising or lowering this piece, regulated to give 300 amperes; which, at the 100 volts to which the primary current had been transformed, was found sufficient to thaw the ordinary service in a few minutes; lead services requiring somewhat longer than iron ones.

The average current used for thawing out a ¾-inch iron service was 5,000 watts; lead and larger iron services requiring somewhat more. Forty-five thousand watts was found sufficient for thawing 150 feet of 6-inch main. From this you can readily estimate the cost; the electric current was, however, not the largest item, the team and four men amounting to much more. More time was consumed in reaching the place and making contact with the wires in the street than in actually thawing the service.

The trouble and expense of making the connection for the primary wires suggests the advisability of a portable electric plant, mounted on wheels, which could be easily transported to the place where it was required.

At times it was found that where several services were frozen near each other two could be thawed at once, and a whole group with one primary connection; this greatly lessened the cost.

In using elecricity for thawing frozen water pipes it is essential to have about 40 h. p., available electric energy, preferably at 100 volts potential, either alternating or direct current. To get satisfactory results it is necessary to force through the frozen section of pipe current sufficient to cause the pipe to offer some resistance; that is, to load the pipe beyond its carrying capacity. Three hundred amperes, at 100 volts, was found sufficient in all cases.

No injury to the pipes seemed to result, at least none has as yet developed; in some instances leaks were started, but this was probably due to the fact that the freezing had burst the pipes.

LEGAL DECISIONS.

T. J. HEALY vs. J. HAMPDEN DOUGHERTY, Commissioner of Water Supply, Gas and Electricity, City of New York, December 1, 1903.

And

KREMENACHER vs. the same.

The Appellate Division of the Supreme Court handed down a decision denying the right of the Commissioner to shut off the water from certain premises in which it was found that the water meter had been tampered with.

The department tried to prove that the present tenant or his agents had knowledge of the condition of the water meter; the court held that the meter had been properly tested by the department and reported to be in good order. The date that the inspector removed the counter of the meter was three years subsequent to the date of test, and the court held that the department did not show that the present tenant filed the teeth so as to cause the meter to register one-fifth of the water which was being received in the premises.

The question as to the amount of water to be charged was not presented to the court.

In the Fall of 1902 the same court handed down a decision, in which all the judges concurred, denying to the owner of a certain house the right to dispute the bill presented by the department. In this case it was found that a pipe was connected with the service behind the meter, and that at the time of inspection the stop-cock controlling the metered supply was shut off and the premises were receiving a supply of water which was not registered. The department attempted to shut off the water for this violation, and the owner secured an injunction restraining the Commissioner. The case was argued and carried to the Appellate Division, that court ruling that the bill presented by the department was just. The bill was computed on a forty-eight hours' consumption of water registered by the meter, and during this period of time an inspector remained on the premises, shut off the unmetered service and recorded the amount of water actually registered by the meter. This basis was carried forward to the time that the business conducted in the premises was first operated, and, as before stated, the court held that the method of computation was fair to the consumer.

STATE OF MINNESOTA—SUPREME COURT.

October Term, 1903.

Roger S. Powell, et al., Appellants.
vs.
City of Duluth, et al., Respondents.

Brief of Respondent.

STATEMENT OF FACTS.

On October 1, 1897, the plaintiffs applied to the Duluth Gas & Water Company for a supply of water for the premises mentioned in this controversy, using the application, Exhibit A, attached to the answer, and water was supplied thereunder. By this application and its acceptance, the plaintiffs agreed to take water through a meter and to pay the meter rate. The meter was put in place by the company and paid for by the plaintiffs. Water was furnished thereafter continuously through this meter until it became out of order, shortly before the institution of this action, and was removed for repair. During all of this time there was in force, governing the price of water furnished to the plaintiffs, a flat rate based upon the size, character and use of the house and of the number of openings through which water was furnished, and a meter rate according to which consumers paid for the actual amount of water used.

A mortgage was given by the Gas & Water Co. covering all of its property, including this contract, and the City of Duluth afterwards acquired title to all of the property of the company, including its contract with these plaintiffs. These plaintiffs continued to use water through the meter and to pay the meter rate. Their use of water was economical and the amount paid at the meter rate was therefore less than the corresponding flat rate would have been, until a short time prior to the institution of this suit, when the use of water became more extravagant or wasteful, so that the price at the meter rate, from January 1, 1901, to September 1, 1901, was from 50 to 55 cents per month more than it would have been at the flat rate.

So long as the use of water was economical and saving, so that the meter rate was less than the flat rate, plaintiffs were satisfied; but as soon as their use of water became such that the flat rate was less than the meter rate, they requested that the meter be taken out and they be placed upon the flat rate.

At all times since the city came into possession of the plant, it had in force a rule provided, in effect, that meters might at any time be placed upon any service, at the option of either the user or the city, and that a meter put on a service could not be removed without the consent of both parties; and that the Water Board should have the right at any time to inspect or remove a meter for repairs.

After appellants had twice applied for permission to remove the meter and pay at the flat rate, and been refused, the meter got out of order. Acting under its rule, the Board removed the meter for repairs. While being rpaired, the water pipes were connected so as not to shut off appellants' supply of water. After the meter was repaired, appellants refused to allow it to be reinstated, and upon the threat of the Board to shut off the supply of water unless appellants would permit the meter to be replaced, this action was brought for an injunction.

It is found by the court "that the flat rates were made as nearly as possible uniform and so as to conform as nearly as possible to the meter rates—allowance being made for the greater waste which is known to exist when water is taken at the flat rate than when it is taken at the meter rate. That water is furnished to consumers as nearly as may be at the cost thereof to the city. That on the average, in the district where the house of plaintiffs is located—the same being a portion of the city occupied by the wealthier classes and where are located the best residences of the city—a very large proportion of the metered houses pay less than like houses on the flat rate; and in portions of the city occupied by those in humbler circumstances, practically none of the metered houses pay the amount of the flat rate for like houses."

It is further found "that about three-fifths of the families using water from the water system of the defendant city pay for it at meter rates, and in dealing with said plaintiffs said Board has not treated them differently than others similarly placed."

The evidence shows that during the management of Mr. Case, eight applications to remove a meter have been made to the Board, of which one was granted, under special circumstances existing in that instance. During all of the time in question, a rule of the Water Board was in force which authorized the management to shut off the supply of water from any consumer when necessary to secure compliance with the rules and regulations or orders of the Board.

Under the city charter and law of the State, the Water Board lays the water mains along the streets and extends the service pipe to the curb. The consumer makes his own connection from the curb line to his dwelling and puts in his own fixtures. The Board has no authority to go upon private property for the purpose of making a connection. It is given authority to condemn private property, where necessary, for the laying of conduits, supply mains or other appliances for supplying water; but no authority is anywhere given to go upon private property for the purpose of making a connection with a building, and, as a matter of practice, that is never done.

The case was tried before the court without a jury; findings were made as shown by the paper book; and an order made for judgment in favor of the defendants. Motion was made for a new trial, which was denied, and this appeal taken.

ARGUMENT.

The amount involved in this case is exceedingly small, so far as the plaintiffs are concerned, being from 50 to 55 cents per month.

The principle is one, the importance of which can hardly be overestimated to the management of the Board of Water & Light Commissioners. The Board, following the universal practice, has adopted two methods of determining the amount of water used and the rate to be paid. Both of these rates are based upon the amount of water consumed. The flat rate is, as shown by the evidence and as counsel says in his brief, largely a guess or estimate; and, as found by the court, is as nearly as possible uniform among the different houses, and as nearly as possible uniform with the metered rate—allowance being made for the greater waste that is known to take place when the water is not measured.

By the rules in force, either the consumer or the city may at any time, if dissatisfied with the flat rate, cause the exact amount of water used to be determined by a meter, and payment made upon that amount. It is evident that the only accurate measurement is that of the meter, and that either party to the contract should have a right to require that method to be used.

In this case, however, it is not necessary to determine the question as to whether or not the Board would have the right to compel a user of water under the flat rate to put in a meter against his consent; although under the decisions which I shall cite there is no doubt about that; but the exact question here is whether or not a consumer, having once installed a meter under the regulations of the Board or of the predecessor of the Board, and having agreed at the time to be bound by the regulations of the Board and to pay for the water at the metered rate, has a right thereafter—notwithstanding he may be using more water than the flat rate is based upon—to demand that the meter be removed and he be given the flat rate.

In other words, can a water user who is now taking water through a meter in quantities sufficient so that he is paying more than the flat rate would be upon his premises, compel the city to put him upon the flat rate and thus to give him his water at a rate less than is being paid by the metered consumers, and at a rate less than is used as the basis for fixing the flat rate?

Or, to put it in still another form, does a consumer, having a contract with the city for the supply of water at the metered rate, have a right to rescind that contract and to compel the city to furnish him water at a rate which he demonstrates to be unequal and unfair, and lower than is being paid by any consumer of metered water, or by the average of those upon the flat rate?

Does a consumer who is paying the uniform and equal rate, and having the water measured in the same manner that 60 per cent. of the users in his class do, have the right to demand that he be given a favored rate and put upon a basis that will permit the use of a greater quantity of water at a lower price?

Does a consumer have a right to repudiate his contract, to over-ride the regulations of the Board, and demand a rate which is unequal and unfair as to other consumers, and which, with the known quantity of water that he is using, makes him a favorite of the Board?

The fact should not be lost sight of, that appellants of their own volition chose the metered method of determining the rate, installed their own meter and used it for a period of years; and that no attempt is now being made to require appellants to go to any additional expense in connection with the installation or maintenance of a meter.

The question is not even whether or not the city has a right to require that the same meter be retained. The prayer of the complaint is, "That the defendants and each of them be restrained and enjoined from invading the plaintiffs' premises for the purpose of placing therein a water meter, either at plaintiffs' expense or otherwise; and from cutting off the water supply from said premises, as is threatened to be done; and that the defendants be required to supply these plaintiffs with water for said premises at the established flat rates."

It appeared from the testimony of one of the appellants that appellants' meter became out of order and was taken out for the purpose of being repaired; and that upon its return they refused to allow it to be placed in the premises, and again applied for a flat rate, which was refused; that the meter is still in the possession of the Board, no request made for its delivery, and that no expense was to be attached to putting it back. It also appeared from the testimony of Mr. Case that if the court should hold it necessary there was no difficulty in putting in another meter; that appellants had never asked for the return of the meter; that it had no value for anything except measuring water; that no complaint was ever made that it was not correct; and that it was of standard make.

The question then is whether or not, under these circumstances, these appellants have, for their own advantage and for the purpose of securing a favored rate and of being able to use water more extravagantly and pay a less amount for it, the absolute right to require that their water be not measured but that it be supplied at the estimated rate.

It is easy to see that to establish that principle would make it impossible for the Board to have a flat or estimated rate. The evidence shows and the court has found, that 60 per cent. of the families using water, take it through a meter, and that with very few exceptions the amount paid at the meter rate is less than the corresponding flat rate—the flat rate being made purposely higher to cover the known waste.

In this case, so long as the metered rate remained lower than the flat rate, appellants did not complain. Immediately after their use of water became extravagant or wasteful enough to put the metered rate above the flat rate, they did complain.

The regulation of the Board, found in Rule 6, prohibiting the removal of a meter without its consent, is made to cover exactly this class of cases; otherwise any person whose use of water is extravagant or wasteful enough under a meter, when it is measured, so that the rate would exceed the corresponding flat rate, would always demand the flat rate; and, of course, his use of water would be enormously increased.

In other words, if, when being paid for by the gallon it is wastefully used, or being used in greater quantities than in other houses of the same character, it can be safely estimated that if water is being paid for on an estimated rate, it will be much more extravagantly or wastefully used.

Under the provisions of the city charter, the Water Board cannot discriminate between users. If it is known in any case by the Board that a water user is using more water than he is entitled to under the rate he is paying, then the Board, under the charter, would have absolutely no right to continue that rate.

In other words: if it were shown that a user, paying under the flat rate, was using, for example, twice the amount of water which he would be entitled to for the same money under the metered rate, the Board could be compelled to require him to put in a meter. The metered rate fixes the real selling rate of the water, and the flat rate is merely an estimate or guess, based upon the average consumption, with some allowance for waste, reaching as nearly as may be the same rate that is in force where the water is metered.

If an attempt were being made to prohibit the putting in of a meter, so that a consumer could pay for exactly what he uses, then a very different question would arise.

The exact question in this case, reduced to its simplest terms, is: Can a consumer, taking water through a meter, when he finds that he is using more water than he would be fairly entitled to under the flat rate then in existnce upon his building, demand as a right that the meter be removed and the water furnished to him under the flat rate: To state the question is to answer it.

Counsel makes in his brief eleven assignments of error. The 1st, 2d, 3d, 4th and 10th are not argued, and therefore, under the rule in this court, are abandoned.

Scott vs. Hay (Minn.), decided October 23, 1903, and cases cited.

The fifth assignment of error is to the admission in evidence of the testimony as to the customs or practice of the Water Board not provided for by written rules. While no reference is given to any such testimony in the discussion of counsel, the only such testimony introduced was that brought out by appellants in their own case.

Appellants' sixth assignment of error is to the finding of the court as to the existence of Rule 6. This assignment is nowhere discussed, that I can determine, but the existence of Rule 6 was alleged in the answer of respondents was not denied in the reply, and was proven by the undisputed evidence of the witness.

The seventh assignment of error assails the 17th finding of fact, which is as to the uniformity of the flat and metered rates, and that the average price paid upon metered houses in the city is less than the corresponding flat rate. Upon this counsel has not attempted to discuss the evidence, and, as a matter of fact, there is no dispute in the evidence and it amply sustains the finding.

The eighth assignment of error assails the finding of the court that there was no discrimination against the plaintiffs. This assignment is not argued, so far as I can see, but the undisputed evidence is that that finding is true. It is shown that during the whole time the management of the plant has been in the hands of the witness Case, there have been eight applications for permission to remove a meter, and that of those eight but one was granted, which was under exceptional circumstances.

The ninth assignment of error challenges a portion of the 7th finding. The finding is not, as assumed in the argument, that the flat rate is based exclusively upon the size, character and use of the house. The only exception that appellants seem to find is that no account is taken of laundry tubs; but a reading of the testimony of Mr. Case will show that that finding of the court is correct.

The inconsistency of counsel's whole position is that he is assailing the flat rate as unfair and inaccurately established, and at the same time is attempting to compel the city to furnish the water to him upon that rate.

That leaves the only question for consideration, that which arises upon assignment of error No. 11; which is that the court erred "11th. In finding that the defendants were entitled to judgment against the plaintiffs."

I am not certain that this raises any question at all. It raises no question unless it is that the findings of fact did not support the conclusion of law. The point is made by respondents that this assignment is too general to raise the question, and that under the rules of the court, the question of whether or not the findings of fact support the conclusions of law, cannot be considered.

Should the court hold, however, that this assignment is sufficient, then I submit the following:

Appellants' contention is apparently based upon two propositions: (1) That water rates are taxes, and that therefore there can be but one method of determining the rates; and (2) that, the city having adopted two methods of determining the rates, appellants must be allowed to elect between them.

Neither position is sound. The first proposition—that water rates are taxes, and that therefore the constitutional provisions as to uniformity of taxation, and the decisions of the courts requiring uniformity of taxation, applies—has been repeatedly denied; and so far as I have been able to find has never been upheld. It has been denied in the following cases:

Wagner vs. Rock Island, 146 Ill. 139; Silkman vs. Board, 152 N. Y. 327; Amt. vs. Cincinnati (Ohio 1897), 35 L. R. A. 736; Providence Institution vs. Jersey City, 113 U. S. 506; Vreeland vs. O'Neil, 36 N. J. E. 399; Vreeland vs. Jersey City, 43 N. J. L. 135 (37 N. J. E. 574); Jones vs. Board, 34 Mich. 273; Preston vs. Board, 76 N. W 92 (117 Mich. 589).

In the case of Jones vs. Board, *supra,* the question was whether or not the Board of Water Commissioners of Detroit, Mich., had authority to make assessments upon lots in front of which water pipes were laid, which did not pay water rates; it was held that it could be done. Under the Act incorporating this Board, the charges for water furnished were made a lien upon the land, which might be enforced in the same manner as a tax lien. In discussing the case, the court said:

By Justice Campbell: "The water rates paid by consumers are in no sense taxes, but are nothing more than the price paid for water as a commodity, just as similar rates are payable to gas companies or to private water works for their supplies of gas or water. No one can be compelled to take water unless he choose, and the lien, although enforced in the same way as a lien for taxes, is really a lien for an indebtedness, like that enforced on mechanics' contracts or against ships or vessels. The price of water is left to be fixed by the Board in their discretion, and the citizens may take it or not, as the price does or does not suit them."

In Preston vs. Board, *supra,* the question arose as to the power of the Board of Water Commissioners of Detroit in fixing rates. That Board had a flat and a meter rate, and the court held that it was sufficient if the two were approximately the same for the same class of property. Among other things they say:

"The Board is very properly given wide discretion in the management of the water plant. There is nothing in the record to show that they have abused this discretion in fixing the rates. We think it is not accurate to speak of these water rates as taxes. All property, except that which is exempt by law, is subject to the payment of taxes; but the use of water is not compulsory. If the owner of property prefer to dig a well or construct a cistern instead of connecting with the system of water works, he (in most instances at least) would be at liberty to do so. It is true, if he is in the water district, he is entitled to the use of the water by complying with the regulations of the Water Board. It is also true that these regulations must be reasonable, but it is not true that they must be uniform or that they must be based upon the value of the property where the water is used."

In Wagner vs. Rock Island, plaintiff sought to enjoin the defendant from shutting off water supplies, upon the ground that water was being furnished to other consumers at a price less than that charged to him. The syllabus is as follows:

"Water rates charged as compensation for the use of water furnished by a city are not an exercise of the taxing power, so as to be within the constitutional requirement as to uniformity of taxation.

"Inequality in water rates resulting merely from the failure of city officers to enforce an ordinance as to some of the consumers does not constitute a cause of complaint to a consumer against whom the ordinance is enforced."

In Silkman vs. Board, 152 N. Y. 327, the syllabus is:

"Rents charged for water actually used are not taxes, so as to entitle persons against whom they are charged to notice and an opportunity to be heard, before the rates are established."

They also hold in that case that "It is proper to charge a higher rate for small quantities than for large quantities.'"

The other position of counsel is in direct conflict with the first proposition. because if absolute uniformity must be secured, as contended for in the first proposition, it requires no argument to show that the only method of securing it is by a meter rate: and the inconsistency of counsel's position is that he is in this case demanding, not the meter rate but the flat rate—the one which from the very nature of things cannot be entirely uniform. Counsel has cited no case which even tends to support his contention upon this point.

The case from 8 Del. Co. R., 151, holds simply that a company cannot establish a minimum rate of $12 for one consumer and of $55 for another, when the two rates should be uniform.

The case from 52 Mo. App., 312, is a direct authority, insofar as it has any bearing at all, for the respondents' position in this case. An ordinance fixed a maximum rate per 1,000 gallons, and fixed an approximate or flat rate in case a meter was not used. Plaintiff erected a residence, piped it and put in a meter. The company refused to turn on the water unless the plaintiff would pay the flat rate.

The section of the ordinance fixing the rate was: "The water rates to consumers shall not exceed 25 cents per thousand gollons or 1 cent per barrel, approximated for the several purposes." Then follows a schedule of prices per annum, and a conclusion: "Rates for all purposes not hereinbefore enumerated, will be fixed by estimate or meter measurement at a rate pro rata to quantity used not exceeding in any instance 25 cents per thousand gallons; provided, however, that the party requiring the meter must pay the expense of the same."

The court held that the question was simply as to the construction of the section, and said:

"The manifest intention of the ordinance was to fix the maximum charge for water at 25 cents per thousand gallons. If the consumer thinks proper, he may decline to go to the expense of a meter and expect the water to be furnished at the approximated or estimated schedule price. If, however, the water company's patron deems it best or to his interest, he is left the choice of placing a meter at his own expense, and then the charge against him is no longer a mere guess or estimate, but he will pay for the water actually used—no more, no less."

What is attempted to be done in this case by appellants is, not to pay for the water actually used, but after it has been demonstrated that they are using more than the average user in the same class of premises and more than the average amount upon which the flat rate is based, to compel the city to furnish water at the flat rate.

In other words, appellants do not seek equality, but seek to compel discrimination in their favor. They do not seek to prevent discrimination against them, but seek to compel the Board to make favorites of them, and seek to compel the Board to violate its sworn duty as imposed upon it by the charter. (Sec. 172.)

Counsel also cites Red Star Line Stmsp. Co. vs. Jersey City, 45 N. J. L., 246. In this case the Board of Public Works of Jersey City attempted to charge a consumer $220 for a meter, and to require payment thereof or upon failure, shut off the water. The court held, construing the different statutes under which the city was supplied with water, that all of the expense of laying pipe, distributing water and adjusting prices to be paid, were to be borne by the city; and that a rental for the use of the water was all that was required of the citizens. It was held that the Board might require the meter to be used, but that on the construction given under their statutes in the case under consideration, the consumer could not be compelled, on pain of shutting off the water, to pay the same. The persons attempted to be charged were tenants, and the meter was in the building when they went into possssion.

The court points out that it would be a great hardship upon a tenant to require it to pay for the meter, which was in the property when it went into possession, but with reference to the right of the city to require the meter to be used, the court said:

"A meter is a contrivance to regulate the distribution of water by adjusting the quantity and price. It is therefore within the province of the city board's duties, to enable them to fix their rates with exactness instead of by an uncertain estimate, and to deal justly with the consumers."

This case may have been correctly decided under the peculiar statutes and peculiar conditions considered, although the case has been severely criticized in State vs. Gosnell, 93 N. W. (Wis.), 542, which case will be referred to hereafter.

But even though it were not based upon the peculiar facts and statutes there considered, the case would not be in point here, for the reason that the cost of the meter in question is but $12 and there is no question of requiring appellants to go to any expense, because they already own the meter and have it installed, and it is of no use to them for any other purpose, and for the further reason that appellants seek not only to prevent the replacing of their meter, but seek to prevent the placing of any meter and to compel the abandonment of any measurement and the adoption of the flat rate.

Counsel also cites the case of American Water Works Co. vs. State, 46 Neb., 194. In this case the court held that a rule of the company requiring payment of $1 before turning on the water, after it had been shut off for failure to pay rents, was unreasonable and void. There is no such question in this case, and any such question that might ever arise would be controlled by Sec. 165 of the charter, which authorizes the shutting off of the water and refusal to turn it on again until the back charges, with the costs and expenses of turning the water off and on, have been paid.

In the case of Wood vs. City of Auburn, 87 Me., 292, it was held that the water company could not shut off the water from a water taker for non-payment of an old, overdue and disputed installment of the water rates, after having accepted payment of a subsequent installment, for the reason, as the court held, that the acceptance of the payment for a subsequent installment was a waiver of the disputed claim.

The case of Merrimac River Savings Bank vs. Lowell, 152 Mass., 556, was of the same character. The water had been cut off for the default of some prior occupant. There was no dispute that it had been wrongfully cut off. The only question was whether or not the city was liable in damages for having wrongfully shut it off.

The case of Griffin vs. Goldsboro Water Co., 122 N. Car, 206 (30 S. E., 319), was an action to restrain the water company from enforcing, as against the plaintiff, a discriminating rate. There was no claim that the rates were uniform. It was admitted that the rates attempted to be charged the plaintiff were much higher than those charged other persons under similar circumstances. The case was not a final detemination, but only passed on the correctness of an order continuing a restraining order. It was correctly decided, but has no bearing upon this question.

The other cases cited by counsel do not seem to have any application at all to this case.

No question is made in this case as to the reasonableness of the rates, and no claim is made of any discrimination against the appellants. The Water Board is a legislative body empowered by the charter to fix rates and to make all reasonable rules and regulations for the conduct and management of the plant. Sec. 163 provides: "The Board shall regulate the distribution and use of the water in all places and for all purposes where the same shall be required for either public or private use, and fix the price and rates therefor." The charter also provides, by Sec. 166, that the Board may make and enforce such by-laws, regulations and ordinances as may be necessary to carry into effect the object and intent of the Act. Under this authority, the rates, metered and approximate or flat, have been established by the Board, and rule 6 adopted, giving to the consumer or to the Board the right to require the water to be metered so as to determine the actual amount used, rather than to have it paid for upon the basis of a guess, as counsel claims the flat rate is.

The question here is not whether the Board might compel the appellants to change from the flat to the metered rate, or whether it could resist appellants' demand for a change from a flat to a metered rate; but it is whether, while appellants are using water under the metered rate, they can compel the city to furnish it to them under the flat or approximate rate.

Appellants do not claim to have any contract with the city or with any one else to have water at the flat rate; they do not claim there is any rule or regulation of the Board which permits them to demand water at the flat rate. They have established the fact that for the Board to furnish it to them at the flat rate would be for the Board to discriminate in their favor.

I have been unable to discover any basis at all for appellants' contention that they are entitled to be served at a rate which, they claim, is based upon a mere guess, and which thy claim is inaccurate. It cannot be upon the basis of their right to be uniformly treated, because that would require payment at the metered rate.

If the city were attempting (as they did in the case from the Mo. App.) to require appellants to pay a flat rate in excess of the rate based upon the actual amount used, then they would have just cause of complaint; but when there is no claim made that the metered rate is not fair; no claim made that it is excessive or higher than it should be; no claim made that the city has ever agreed in any way by any rule or regulation or by any contract of any kind, to furnish appellants with water at the flat rate; it is impossible for me to discover the theory upon which appellants seek to base their claim.

No case has been found in the books where such a contention as this was made. Cases may be found where a question arose over the right to require the water user to install a meter, or over the right of the seller of the water to require that it be accurately measured, but I have found no case which discusses the right of the consumer of water, taking it through a meter, to demand that his meter be removed and he be permitted to pay a less amount, based upon an approximated rate, with no rule or regulation of the seller authorizing it, and in the face of a rule or regulation of the seller forbidding it.

In the charter of Greater New York, the Commissioner of Water Supply is authorized in his discretion to cause water meters to be placed in certain classes of buildings, and this regulation is assumed to be valid in Foster vs. Monroe, 82 N. Y. S., 653.

In Exchange Bldg. Co. vs. Roanoke Gas & Water Co., 90 Va., 83 (17 S. E. 789), it was held that the water company had a right to place a meter on the water pipe conveying water to the plaintiff's building, and to charge the meter rate. The court said, in the course of its opinion:

"There is but one question disputed in this case, the sole question at issue being whether the Roanoke Gas & Water Co., under and by virtue of its charter, is authorized to charge some of the consumers of water or water takers in the city of Roanoke by the gallon and at the same time to charge others by the hydrant, or whether charging some by the hydrant it may, under its charter, nevertheless charge still others by the gallon. * * *

"While it is clear that the water company cannot lawfully discriminate between water takers of the same class, so as to make their rates otherwise than uniform, yet by its charter the water company is authorized to use either the hydrant as a means of charge or use any reliable instrument which will measure the gallons used, and so enable it to charge by the gallon. The water rates must be uniform throughout the town for the same class of service and the water company cannot charge one for water more than another in the same class of service. The complaint in this case is that the water company is about to measure the water used by the plaintiff company. This the charter impliedly authorized when it allowed a charge by the gallon."

In the case at bar the complaint is that the city will not discontinue measuring the water through a meter and charging at the metered rate, although there is no rule or regulation of the Board requiring it, and there is one expressly forbidding it; and although the charter (Sec. 173) expressly authorizes the employment of water meters for the purpose of showing the amount of water used.

Parker vs. City of Boston, 1 Allen, 361, is an old case exactly in point, where the city authorities were upheld in requiring the consumer to take water through a meter, where both a meter and flat rate were in force.

The case of State vs. Gosnell, decided by the Supreme Court of Wisconsin on February 3d of this year, and found in 2 N. W., p. 542, discusses in the exhaustive manner of Judge Marshall, the validity of an ordinance requiring water users of a certain class to install meters at their own expense; and the validity of the ordinance was upheld. In the course of the opinion it is said:

"Under either the provision for the prevention of waste or the provision to make regulations for ascertaining the amount to be paid by consumers of water, the requirement contained in the ordinance, for consumers in certain classes to use meters and to provide and keep them in repair at their own expense, is legitimate. It is a matter of common knowledge that the use of meters has a double purpose, and that the dominant one as regards the party furnishing the opportunity to take water, is to prevent useless consumption thereof. Secondary to that, and more for the benefit of the consumer than the party responsible for keeping up an adequate supply of water under proper pressure, is the measurement of the water. The consumer is burdened with the expense of providing a meter and keeping it in repair, but has the countervailing advantage, by the exercise of prudence in the use of the water, of paying only for the amount actually taken from the public supply, which in most cases, by reasonable attention, can be made much less than what he would be required to pay by the schedule of rates where meters are not used."

The court points out that the consumer is to pay all of the expenses of the connection from the service pipe laid in the street, in which the case at bar coincides. The court then discusses the case from New Jersey and criticizes it, calling attention to the fact that by that case it was assumed that it was the duty of the seller of the water to pay all expenses of every kind of distributing it, while under the Wisconsin law, as it is in the case at bar, the consumer of water takes it from the service main in the street and the expense of the connection is his. Proceeding further, the court says:

"In general the primary purpose of using water meters is to prevent unnecessary use of water. Many consumers habitually abuse the privilege to take water. They may do it in a way difficult to detect, and to greatly impair the efficiency of the water service for many purposes—fire protection and the operation of motors being significant among them. Meters are used to guard against the danger of carelessness in leaving faucets and hydrants open when there is no necessity therefor."

The court also considers and quotes at length from an English case, Sheffield Water Works Co. vs. Bingham, L. R. 25, Chi. Div. 443, in which the court held that the water company had a right to require the consumer at his own expense to provide a water meter.

In the case of Hill vs. Thompson, 16 Jones & S. 481, the court upheld the regulation of the New York charter authorizing the Commissioner of Public Works, in his discretion, to place a meter upon the premises at the expense of the consumer. The law was assailed as unconstitutional, and the right of the commissioner in the exercise of his discretion to place a meter in any building within the classes designated by the charter at the expense of the consumer, was upheld; although the only use of the meter was to check the waste of water, as there was still a minimum rate which must be paid, notwithstanding at the meter rate the amount of the charge might be lower; and it was held that the objection urged against the statute conferring this discretionary power on the commissioner was clearly untenable.

This case was afterwards cited with approval in the case of Moffat vs. Henderson, 18 Jones & S. 211, and also in the case of Silkman vs. Water Commissioners, 152 N. Y. at 331.

In Sweeny vs. Beinville Water Supply Co., 131 Ala. 454 (25 So. 575), the employes of the water company, while attempting to put in a meter or turn off the water from a consumer's premises, were threatened with violence by the consumer, who was thereupon prosecuted for disorderly conduct. In a suit brought by him for malicious prosecution the court held that in the absence of a contract to furnish water to the consumer for a definite time, the water company might shut off the supply at any time for refusal to comply with the newly adopted rule requiring the placing of meters and the payment for water at meter rates.

In Sheward vs. Citizens' Water Co., 90 Cal. 635 (27 Pac. 439), the Supreme Court of California upheld the validity of an ordinance regulating the rates and compensation, which gave to the water company the right to apply a meter and collect metered rates. A meter was placed upon the service, and the metered rate proved to be higher than the flat rate fixed by the same ordinance. The company refused to accept this amount, threatened to shut off the water unless the correct amount was paid, and an action for injunction was brought. It was argued, as it is here, that the fact that two rates were established enabled the water company to discriminate between consumers of the same class. The court held that it was not necessary that absolute uniformity be reached between the metered rate and the estimated rate; and further state that the fact that this provision for rates, in the absence of exact measurement, will only, as a general rule, be equivalent to the rates charged by measurement, and may result in an inequality of individual rates, affords an illustration that in practical legislaton absolute perfecton is unattainable.

Under the ordinance in question, either the consumer or the water company had a right to require the water to be metered. In that respect the ordinance was identical with the rule under consideration. The court said, speaking of the estimated rates:

"If the consumer is of the opinion that they call for greater compensation than is authorized by the amount of water which is actually supplied to him, he has the right to have his exact consumption ascertained and rated; and if, on the other hand, the company is of the opinion that the consumer makes use of a greater amount of water than is justified under the estimate made in fixing the rates for specific uses, it can attach a meter and receive compensation for the exact amount consumed. In either case there is nothing unjust or inequitable to either party, since in each the company receives and the consumer pays for the exact amount of water supplied; nor can it be said that the ordinance itself furnishes any opportunity for discrimination or distinction between its customers. The objecton that the meter may be incorrect in measurement cannot be considered. A meter is a measurer, and we must assume that it correctly measures and determines the water which passes through it."

In the case at bar, no question has ever been made that the meter was inaccurate.

From this examination of the cases, which I think may be accepted as reasonably exhaustive, the following propositions seem to me established:

It is held by every court that has ever considered the question, that a rule or regulation giving to either party the right to require the water used to be measured by a meter and the amount thus determined to be paid for at the establishd rate, is valid.

The only question upon which there has been any difference of opinion has been as to whether or not the installation of the meter in the first instance could be required of the water consumer, and upon this proposition there have been diverse views, apparently based upon special statutes.

In England, as pointed out by Judge Marshall in the case of State vs. Gosnell, cited above, the two cases which seem to have considered the question have reached different results, although the later decision, which, to some extent, criticizes and overrules the former, holds that the consumer should pay for the meter, as much as for the service pipe leading to his house, or for any part of the distributing pipes in his house.

The question seems to have first arisen in this country in the case from Jones & Spencer, in New York, which was decided in 1882, and which established for that State the right of the Water Commissioner to require the meter to be put upon the service at the expense of the consumer. That practice is still followed in New York, as shown by the case of Foster vs. Monroe, cited above.

The case from New Jersey is the only case cited by counsel in which the right to require the consumer to pay for the meter was passed upon; and in that case, based upon its special facts and peculiar statutes, the right was denied.

The question, under conditions identical with ours, arose in the Wisconsin case cited above, and there, after an exhaustive review of all of the authorities upon the question, it was held that a regulation requiring the consumer to install a meter at his own expense upon the demand of the company, was valid.

While it cannot be said that upon this question the cases are unanimous, there being one earlier case in England

and the New Jersey case, which, under their peculiar circumstances, deny the right of the company to require the consumer to pay for the meter, still the later and better considered cases and the only case at all analogous upon the facts to one that could arise in this city, uphold fully the right of the company under such regulation to require the meter to be installed and at the expense of the consumer. This is based upon the ground that the meter is placed within private property, is to enable the consumer to measure the water used by him, and that the entire expense of everything outside of the city's distributing plant, which only extends to the curb line, is borne by the consumer.

There has never been any dispute, however, from the time of the earliest cases, upon the proposition that a regulation giving to either party the right to require the water to be measured and the amount used accurately determined and paid for, will be upheld; and that is as far as it is necessary to go in this particular case, as the appellants seek to compel the city to give them the flat rate and to prevent the city from reinstating the meter owned by appellants or any other meter.

The earliest case I have found is that of Parker vs. City of Boston, cited above, which was decided by the Supreme Court of Massachusetts in 1861, and the plaintiffs were required to pay the meter rate, although that charge was higher than the minimum rate at which it might have been allowed to be taken, and although it was shown that meters were not required to be placed in all buildings of the same character.

The same proposition was upheld in the Virginia case cited above, as well as by the cases from Alabama, California, Wisconsin and New York.

The right of the city to require the water to be paid for at the metered rate being established, no question can be made of the right of the Water Board to enforce the payment of that rate by shutting off the water. The right of the Board to shut off the water for failure to pay the water rates is expressly given by the charter (Sec. 165). The Water Board is also empowered (Sec. 166) to make and enforce such by-laws, regulations and ordinances as may be necessary to carry out the object and intent of the charter creating it; and one of the rules enacted under authority of the charter give it the right to shut off the water to secure compliance with any of its rules and regulations. That such a right will be upheld, even in the absence of the authority given in the charter, cannot be disputed. The authorities are uniform.

Without any attempt to be exhaustive, the following may be referred to:

Sheward vs. Citizens' Water Co., 90 Cal., 635 (27 Pac., 439); McGregor vs. Case, 80 Minn., 214; Shiras vs. Ewing, 48 Kan., 170 (29 Pac., 320); Watauga Water Co. vs. Wolfe, 99 Tenn., 429; Hieronymous Bros. vs. Bienville Water Supply Co., 131 Ala., 447 (31 So., 31); Krumenaker vs. Dougherty, 77 N. Y. S., 467; Harbison vs. Knoxville Water Co., 53 S. W., 993; Takoma Hotel Co. vs. Takoma Light & Water Co., 3 Wash., 316 (28 Pac., 516); Brass vs. Rathborn, 153 N. Y., 435; Jones vs. Nashville, 72 S. W., 985; Atlanta vs. Burton, 90 Ga., 486 (16 S. E., 214).

See also cases cited in American Water Works Co. vs. State, 46 Neb., 194.

The decision of the court below is right, and should be upheld. Respecftully submitted,

OSCAR MITCHELL,
Attorney for Respondent.

CHANCERY CASE NO. 8368,
KNOX COUNTY, STATE OF TENNESSEE.

ALBERT CHEVANES AND WIFE
VS.
KNOXVILLE WATER COMPANY.

IN RE-MINIMUM METER RATE.

Held, That a rule reading, "That a minimum meter charge shall not be less than $10.00 per annum for each dwelling, store and other premises supplied thereby, and only one such store, dwelling or other premises shall be attached or supplied by one service pipe or meter, except by and with the consent of the Water Company, and upon written application of the owner that he will pay therefor not less than $10.00 per annum for each of the said dwellings, stores or other premises authorized to be supplied thereby, whether water to that amount shall be used or not," is valid and reasonable.

OPINION OF CHANCERY COURT OF APPEALS.
DECREE OF CHANCERY COURT OF APPEALS.
OPINION OF SUPREME COURT.
DECREE OF SUPREME COURT.

LIST OF MEMBERS

HONORARY.

	Date of Membership.
Bement, R. B. C. St. Paul, Minn	1888
Cameron, W. L. 1219 Leighton Ave., Anniston, Ala	1881
Foster, J. F. Room 43, 92 La Salle St., Chicago, Ill	1881
Holly, Ira A. 129 East 59th St., New York City	1881
Holman, M. L. 1324 Chemical Bldg., St. Louis, Mo	1881
Nakijima, Y. Imperial University, Tokio, Japan	1887
Watts, Sylvester St. Louis, Mo	1881

ACTIVE.

Adkins, B. C. Water Comr., 312 City Hall, St. Louis, Mo	1900
Affleck, John A. Water Comr., Harrisburg, Pa	1899
Ahearn, John T. Supt. Water-Works, Nashville, Tenn	1901
Aiken, Henry M. Res. Mgr. Water Co., Knoxville, Tenn	1904
Alexander, W. A. 1007 Ross Ave., Wilkinsburg, Pa	1890
Alderman, C. L. Manager Water Co., Big Springs, Tex	1904
Alvord, John W. Cons. Engr., 127 Hartford Bldg., Chicago, Ill	1899
Amsbary, F. C. Mgr. Champagne & Urbana Water Co., Champagne, Ill.	1902
Anderson, J. F. Meter Supt., 1737 Washington St., Kansas City, Mo	1903
Anderson, John Secy. and Supt. Water-Works, Binghamton, N. Y	1903
Anderson, L. W., City Engr., Grand Rapids, Mich	1901
Andrews, Lewis P. Pres. Water & Light Co., Sedalia, Mo	1904

Name	Occupation and Address	Date of Membership.
Artingstall, Samuel G.	Civil Engr., 13 S. Hamilton Ave., Chicago Ill.	1890
Ashley, Burton J.	Cons. Engr., Chicago, Ill.	1902
Babcock, S. E.	Hydraulic Engr., 54 Mann Bldg., Utica, N. Y.	1886
Bacot, R. C.	Insp. Meter Dept., P. O. Box 221, Port Chester, N. Y.	1894
Bain, Ernest B.	Supt. Wake Water Co., Raleigh, N. C.	1904
Baker, M. N.	Assoc. Editor Engineering News, 220 Broadway, New York, N. Y.	1903
Bancroft, P. T.	Supt. Water-Works, Rock Island, Ill.	1903
Barker, W. H.	Sec. of Board of Water-Works Trustees, Sioux City, Ia.	1903
Barron, A. M.	Supt. Southwest Missouri Light Co., Joplin, Mo.	1902
Bassett, George B.	Civil Engr., 363 Washington St., Buffalo, N. Y.	1898
Bauman, C. V.,	Water Comr., Newark, N. J.	1900
Baxter, Francis K.	Civil Engr., 46 Arcade, Utica, N. Y.	1903
Beardsley, Joseph C.	689 The Arcade, Cleveland, Ohio	1903
Bemis, Edward W.,	Supt. Water-Works, 178 Kensington St., Cleveland, O.	1903
Bennett, Thos. H.	Supt. Water-Works, Oswego, N. Y.	1898
Benzenberg, G. H.	Cons. Engr., 436 Jefferson St., Milwaukee, Wis.	1888
Berry, J. P.	Supt. Water-Works, Waterloo, Ia.	1896
Bettes, Charles R.	Chf. Engr. Queens Co. Water-Works, Far Rockaway, L. I., N. Y.	1901
Brightman, Horace I.	Sec. Staten Island Water Supply Co., 50 Broadway, New York, N. Y.	1902

	Date of Membership.
Binder, Frederick C. Asst. Supt. and Treas. Water Co., Jefferson City, Mo.	1904
Bishop, John L. Sec. and Supt. Water-Works, Salina, Kan.	1893
Bissett, Edwin H. Metals Broker, Winnipeg, Man.	1898
Boardman, Arthur Edwin Pres. Tampa, Fla., Water-Works Co., 44 Broad St., New York, N. Y.	1903
Boardman, W. H. Civil Engr., 2203 E. Dauphin St., Philadelphia, Pa.	1893
Boeh, W. H. Chief Engr. Water-Works, Cincinnati, Ohio	1900
Bogart, John Civil Engr., 16 Exchange Pl., New York, N. Y.	1892
Bolger, F. E. Secretary Water Works, City Bldg., Springfield, O.	1903
Bolling, Charles E. Supt. Water-Works, Richmond, Va.	1891
Bond, Joseph A. Civil Engineer, Wilmington, Del.	1888
Booker, George E. Chief C. S. V. W. W. Co., 126 Stockton St., San Francisco, Cal.	1891
Brackenridge, Geo. W. Pres. Water Co., San Antonio, Tex.	1888
Brooks, Isaac W. Pres. Water Co., Torrington, Conn.	1889
Brotherton, Charles F. Mgr. Water Co., Ashtabula, Ohio	1904
Brough, Walter Constantine C. E., Goderich, Can.	1897
Brown, A. L. Supt. Water-Works, Salem, Ore.	1888
Brown, Calvin S. Water Comr., 2228 Glenwood Ave., Toledo, Ohio	1882
Brown, Lew O. Supt. Water-Works, Carthage, Mo.	1902
Bunting, N. W. Elmira, N. Y.	1901

		Date of Membership.
Burleigh, John J.	Sec. and Treas. Merchantville Water Co., 5th and Market Sts., Camden, N. J.	1895
Burnett, M.	Supt. Water-Works, Paducah, Ky.	1889
Cahill, Stephen	Supt. of Water-Works, Manistee, Mich.	1890
Cain, W. L.	Supt. of Water Co., Tyler, Texas	1903
Caird, James M.	Chemist and Bacteriologist, 271 River St., Troy, N. Y.	1900
Calhoun, H. L.	Sec. Water-Works, Fort Worth, Texas	1904
Campbell, Charles H.	Supt. Water-Works, Charlotte, N. C.	1895
Campbell, James J.	Supt. Water-Works, Menominee, Mich.	1902
Cappelen, F. W.	Cons. Engr., 610 Globe Bldg., Minneapolis, Minn.	1893
Carlson, J. A.	Water Comr., Stromsburg, Neb.	1904
Carroll, Daniel W.	Battalion Chief and Supt. Water, 146 Pine St., Detroit, Mich.	1903
Carroll, Eugene	Chief Engr. and Supt. Water Co., Butte, Mont.	1904
Case, E. W.	City Engr., Colorado Springs, Colo.	1902
Case, L. N.	Mgr. and Sec. Water and Light Dept., Duluth, Minn.	1889
Caulfield, John	Sec. Water-Works, St. Paul, Minn.	1887
Chapin, L. E.	Cons. Engr. Water-Works, Canton, Ohio	1890
Charles, S. A.	Supt. Water-Works, Lexington, Ky.	1894
Chatham, J.	Supt. Water-Works, Iowa City, Ia.	1892
Chipman, Willis	Civil Engr., 103 Bay St., Toronto, Can.	1888
Chisham, J. M.		

Date of Membership.

Dir. Water Co., Atchison, Kan........................ 1902

Clark, D. H.
Clerk City Water-Works, Ironton, Ohio............... 1904

Clark, H. W.
Treas. and Genl. Mgr. Clear Water Co., Mattoon, Ill..*1895-1903

Clark, J. V.
Supt. Citizens' Water Co., Washington, Pa............. 1903

Clayton, R. M.
City Engr., Atlanta, Ga................................ 1891

Cobb, Charles H.,
Supt. Water-Works, Kankakee, Ill..................... 1904

Cole, Edward S.
Hydraulic Engr., 220 Broadway, New York, N. Y...... 1902

Cole, John A.
Hydraulic Engr., Old Colony Bldg., Chicago, Ill.......*1889-1902

Conard, W. R.
Inspector of Materials, 1102 High St., Burlington, N. J.. 1904

Conlin, F.
Water Comr., 355 Market St., Bethlehem, Pa........... 1904

Connor, F. J.
Supt. Water-Works, Faribault, Minn.................. 1900

Cook, F. S.
Asst. Engr. Croton Aqueduct Commission, 26 Landscape Ave., Yonkers, N. Y................................. 1904

Cook, Henry A.
Supt. Water-Works, Salem, Mass...................... 1897

Cook, T. R.
Superintendent Water-Works, Toledo, Ohio............ 1897

Crandall, William S.
Editor Muncipal Journal and Engineer, 253 Broadway, New York, N. Y.................................. 1901

Croes, J. J. R.
Cons. Engr., 68 Broad St., New York, N. Y........... 1882

Croll, Emil A.
Supt. Water-Works, Iron Mountain, Mich............. 1893

Cuddeback, Allen W.
Engr. and Supt. Passaic Water Co., Paterson, N.J...... 1904

Davis, F. A. W.
Vice-Pres. and Treas. Water Co., Indianapolis, Ind.......1886

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*Resigned and re-elected.

		Date of Membership.
Davy, T. W.	Supt. Water-Works, Middletown, N. Y.	1901
Deery, John Jerome	Archt. and Engr., Betz Bldg., Philadelphia, Pa.	1901
Deffenbaugh, J. M.	Water Comr., Lincoln, Neb.	1904
Dennis, Charles E.	Supt. Water-Works, Watkins, N. Y.	1904
DeSaussure, William P.	Vice-Pres. Vinton-Roanoke Water Co., 1103 Main St., Richmond, Va.	1900
Devine, P. H.	Superintendent of Public Works, Ishpeming, Mich.	1903
Dill, H. A.	Superintendent Water-Works, Richmond, Ind.	1900
Diven, J. M.	Superintendent Water-Works, Elmira, N. Y.	1884
Donahue, J. P.	Secretary and Treasurer Water Co., Davenport, Iowa.	1884
Dow, A. R.	Superintendent Water-Works, Salem, Ohio.	1902
Drummond, M. J.	President Green Island Water Supply Co., Green Island, N. Y.	1901
Dunbar, E. L.	Secretary and Superintendent Water-Works, Bay City, Mich	1886
Dunbaugh, George J.	President Water Company, Pueblo, Col.	1897
Dunham, H. F.,	Consulting Engineer, 220 Broadway, New York, N. Y.	1884
Durlin, Willis B.	Water Commissioner, Erie, Pa.	1903
Eaton, Harvey D.	Council for Water District Trustees, Waterville, Me.	1903
Eggers, August F.	Water Commissioner, Newark, N. J.	1904
Elbert, Edward	Water Commissioner, Reading, Pa.	1904
Ellsworth, Emory A.	Civil and Hydraulic Engineer, Holyoke, Mass.	1904

	Date of Membership.
ELLWANGER, JOHN President Water-Works Trustees, 1392 Main St., Dubuque, Iowa	1903
ELLIS, ROBERT N. Civil Engineer, Jacksonville, Fla.	1890
ELLISON, B. F. General Manager Superior Water, Light and Power Co., West Superior, Wis.	1893
EMERY, EZRA L. Supt. Green River Water-Works Co., Rock Springs, Wyo..	1897
ERICSON, JOHN City Engineer, Chicago, Ill.	1897
FAIRFIELD, E. M. General Manager Water Co., Omaha, Neb.	1902
FANNING, J. T. Consulting and Civil Engineer, 330 Hennipen Ave., Minneapolis, Minn.	1886
FARLEY, JOHN M. Consulting Engineer, White Plains, N. Y.	1902
FELIX, GEORGE H. General Manager Water-Works, Reading, Pa.	1893
FELLOWS, C. L. Deputy City Engineer, Toronto, Can.	1904
FISHER, E. A. City Engineer, Rochester, N. Y.	1901
FITCH, W. P. Superintendent Water Department, Mason City, Ia.	1904
FORBES, MURRAY Superintendent and Secretary Irwin Water Co., Greensburg, Pa.	1891
FORD, EDWIN H. Superintendent Water-Works, Hartford City, Ind.	1901
FOSTER, ERNEST H. Mechanical Engineer, 126 Liberty St., New York.	1901
FOX, CHAS. J. Superintendent Water Co., Cedar Rapids, Ia.	1902
FRAILEY, E. F. Superintendent Water-Works, Lancaster, Pa.	1896
FRENCH, D. W., Supt. Hackensack Water Co., Weehawken, N. J.	1895

	Date of Membership.
FULLER, ALLEN J., General Superintendent Bureau of Water, City Hall, Philadelphia, Pa.	1901
FULLER, GEORGE W. Consulting Expert Water Purification, 170 Broadway, New York, N. Y.	1898
GAILEY, S. A. Superintendent Water Department, Altoona, Pa.	1899
GALLEGHER, JOHN F. Superintendent Water Works, Kingston, N. Y.	1904
GANNON, THOMAS W. Superintendent Water-Works, Cairo, Ill.	1904
GARDNER, L. H. Superintendent Water Co., New Orleans, La.	1883
GARRISON, RALPH H. Superintendent of Public Works, 817 Wood St., Vineland, N. J.	1904
GATES, H. V. President Prineville Water & Light Co., Hillsboro, Ore.	1904
GEDNEY, JEROME D. Chairman Water Committee, East Orange, N. J.	1903
GETCHELL, WILLIAMS BASSETT City Engineer, Augusta, Me.	1904
GLAZIER, W. L. Superintendent Water-Works, Newport, Ky.	1902
GLORE, W. H. Superintendent Water Co., Covington, Ky.	1890
GLOVER, ALBERT S. Secretary Hersey Mfg. Co., 714 Tremont Temple, Boston, Mass.	1885
GRIFFIN, J. WILLIAM Superintendent New Jersey Suburban Water Co., Arlington, N. J.	1904
GOODELL, J. M. Hydraulic Engineer, Editor Engineering Record, 114 Liberty St., New York, N. Y.	1894
GOODNOW, W. T. General Manager Water Co., Sayre, Pa.	*1889-1903
GOODWIN, WM. G. Superintendent and Engineer Water-Works, Kansas City, Mo.	1902

		Date of Membership.
Gould, Uriah	Chief Engineer Pumping Station, Detroit, Mich.	1903
Gubelman, Fred J.	Care of Eastern Construction Co., 32 Nassau St., New York, N. Y.	1897
Guilford, Andrew J.	Mechanical Engineer, The Rookery, Chicago, Ill.	*1889-1903
Gwinn, Dow R.	President Water Co., Terre Haute, Ind.	1893
Hague, C. A.	Consulting Engineer, 114 Liberty St., New York, N. Y.	1886
Hale, A. K.	Treasurer and Manager Water Co., Ann Arbor, Mich.	1903
Hall, J. W.	Manager Water Co., Stockton, Cal.	1904
Hamilton, W. S.	Superintendent Water-Works, Youngstown, Ohio	1883
Hand, F. L.	Chief Engineer, Bureau of Water, Philadelphia, Pa.	1901
Harbster, M.	Water Commissioner, Reading, Pa.	1901
Hardy, A. W.	Inspector and Hydraulic Engineer, 240 LaSalle St., Chicago, Ill.	1904
Harlow, George R.	Constructing Engineer, 620 Wood St., Wilkinsburg, Pa.	1884
Harlow, James H.	Consulting Engineer, 1402 Continental Trust Bldg., Baltimore, Md.	1891
Hart, Ed. W.	General Manager Water Co., Council Bluffs, Ia.	1896
Hatton, T. Chalkley	Consulting Engineer, 608 Market St., Wilmington, Del.	1902
Hawks, W. E.	President and Treasurer Water-Works, Bennington, Vt.	1892
Hazen, Allen	Civil Engineer, 220 Broadway, New York, N. Y.	1896
Healey, G. B.		

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*Resigned and re-elected.

	Date of Membership.
President of Board of Trustees, 316 Toy Building, Sioux City, Iowa	1903
HEEGER, EMIL I. Member Water-Works Board, Evansville, Ind.	1902
HEERMANS, H. C. Superintendent Water-Works Co., Corning, N. Y.	1886
HEIM, J. B. Superintendent Water-Works, Madison, Wis.	1893
HEISLER, CHARLES L. Mechanical Engineer, 714 Westinghouse Bldg., Pittsburg, Pa.	1904
HENDERSON, CHARLES R. Superintendent Water-Works, Quincy, Ill.	1901
HERING, RUDOLPH Hydraulic and Sanitary Engineer, 170 Broadway, New York, N. Y.	1887
HERMANY, CHARLES Chief Engineer and Superintendent Water-Works, Louisville, Ky.	1889
HERSCHEL, CLEMENS Hydraulic Engineer, 2 Wall St., New York, N. Y.	1892
HIBBELER, H. D. Secretary and Treasurer Water Co., Washington, Mo.	1904
HIGBEE, I. M. Superintendent Water-Works, Lewisburg, Pa.	1904
HILL, JOHN W. Consulting Engineer, 35 and 36 Glenn Bldg., Cincinnati, Ohio	1886
HILL, NICHOLAS S., JR. Civil Engineer, 100 William St., New York, N. Y.	1901
HILL, WILLIAM R. Consulting Engineer, 242 Sixth Ave., Brooklyn, N. Y.	1897
HOBBS, A. L. Superintendent and Secretary Water-Works, Raton, N. Mex.	1902
HODGKINS, H. C. Civil Engineer, 508 Kirk Bldg., Syracuse, N. Y.	1888
HOLMES, ALBA L. Hydraulic Engineer, 574 Wealthy Ave., Grand Rapids, Mich.	1900

		Date of Membership.
Hood, Charles	Buffalo, Kan.	1886
Hooper, Thomas N.	Vice-President Water Co., Davenport, Ia.	1884
Hopkins, James A.	Superintendent Water-Works, Colorado Springs, Col.	1897
Horner, Charles M.	Assistant Superintendent Water-Works Co., 803 Ohio Ave., East St. Louis, Ill.	1903
Hornung, George	Consulting Civil and Mechanical Engr., Bellevue, Ky.	1887
Horton, Horace E.	Civil Engineer, Chicago Bridge & Iron Co., Chicago, Ill.	1904
Houston, George	Water Commissioner, Kalamazoo, Mich.	1904
Hubbell, Clarence W.	Civil Engineer Water Board, Detroit, Mich.	1903
Huggins, D. E.	Manager Water-Works, Streator, Ill.	1896
Hulley, Elkanah	Superintendent Water-Works, Marion, Ind.	1898
Humphreys. William Henry	Engineer, Manager and Secretary Water-Works Co., Lendal Bridge, York, England	1904
Hunter, W. J.	Manager Charters Valley Water Co., 235 Orchard St., Knoxville, Pittsburg, Pa.	1903
Hutton, George J.	Water Commissioner. Harrisburg, Pa.	1904
Hutzel, Titus F.	Superintendent Water Co., Ann Arbor, Mich.	1903
Jackson, Robert A.	Superintendent Insurance & Water Co., Norristown, Pa.	1903
Jefferis, Louis M.	Constructing Engineer, 623 Vennica Ave., East St. Louis, Ill.	1904
Jones, A. J.	P. O. Box 373, New Brunswick, N. J.	1884
Jones, George L.	Engr. Water-Works. Lorain, Ohio	1901

		Date of Membership.
Kastberg, Karl C.	City Engr. and Supt. City Water-Works, Boone, Ia.	1904
Keeler, H. E.	Pres. Rogers Park Water Co., 97 South Clinton St., Chicago, Ill.	1887
Kelley, John C.	Director Water-Works, 84-86 Chambers St., New York, N. Y.	1890
Kelley, Frank J.	Supt. Meter and Hydrant Service, Water-Works, 12 East Seventh St., Cincinnati, Ohio	1903
Kelley, Nicholas J.	Supt. DePew and Lake Erie Water Co., 1361 Abbott Road, Buffalo, N. Y.	1903
Kellogg, R. M.	Supt. Middlesex Water Co., Metuchen, N. J.	1901
Kemp, John Edward	Supt. Water Department, Kewanee, Ill.	1904
Kennedy, George G.	Supt. Water-Works, Harrisburg, Pa.	1904
Kimball, Frank C.	14 Beacon St., Boston, Mass.	1902
King, Adolphe J.	Genl. Mgr. Water-Works, Alamogordo, New Mex.	1904
Kingsley, Marvin W.	Civil Engr., Rose Bldg., Cleveland, Ohio	1899
Knox, H. E., Jr.	Hydraulic Engineer, Piedmont Bldg., Charlotte, N. C.	1901
Knox, W. F.	Sec. Water Company, Tyler, Tex.	1896
Knudson, A. A.	Electrical Engr., 34 Nassau St., New York, N. Y.	1900
Koenig, Arnold C.	Sec. Board of Water Commissioners, 514 Bee Building, Omaha, Neb.	1901
Kuhn, W. S.	Genl. Mgr. American Water-Works and Guarantee Co., P. O. Box 1103, Pittsburg, Pa.	1886
Kuhn, Jacob	Water-Works Contractor, York, Pa.	1891

		Date of Membership.
Kuichling, E.	Civil Engr., 52 Broadway, New York, N. Y.	1896
Laing, H. H.	Supt. Water-Works, Racine, Wis.	1902
Lancaster, Sam. C.	Sec. and Supt. Water-Works, Jackson, Tenn.	1902
Landes, J. D.	Sec. and Treas. Canajoharie, N. Y., Water Supply Co., Mechanicsburg, Pa.	1904
Lautz, Henry	Supt. Pekin Water-Works Co., Pekin, Ill.	1896
LeConte, L. J.	Civil and Con. Engr., P. O. Box 482, Oakland, Cal.	1886
Leisen, Theodore Alfred	Chf. Engr. Water Dept., Wilmington, Del.	1904
Lefavor, Walter L.	Mgr. Water Co., Springfield, Mo.	1904
Little, Beekman C.	Supt. Water-Works, 44 City Hall, Rochester, N. Y.	1903
Locke, J. W.	Assistant Supt. Water-Works, Brockton, Mass.	1896
Lockwood, Charles A.	Pres. Jamaica Water Supply Co., Jamaica, L. I., N. Y.	1903
Longyear, O. C.	79 Maiden Lane, Kingston, N. Y.	1898
Lord, Harry A.	Supt. Water-Works, Ogdensburg, N. Y.	1903
Lorenz, John	Electric Light & Power Co., Jackson, Miss.	1902
Lovell, Walter D.	Con. Engr., 602 Equitable Bldg., Des Moines, Ia.	1898
Lucas, Fred L.	Mgr. and Sec. Light and Water Co. Pontiac, Ill.	1903
Ludlow, J. L.	Con. Engr., Winston-Salem, N. C.	1904
Lyon, Henry L.	Deputy Water Commissioner, Buffalo, N. Y.	1903
McAlpine, A. H.	Genl. Western Agent Hersey Mfg. Co., 426 N. High St., Columbus, Ohio	1889

	Date of Membership.
McArthur, Arthur Supt. Water-Works, Dubuque, Iowa	1902
McConnell, J. H. Supervisor Water Department, Minneapolis, Minn.	1901
McConnell, W. C. Pres. Water Company, Shamokin, Pa.	1888
McCorkindale, Wm. J. Supt. Harvey Water and Light Co., Harvey, Ill.	1903
McCormick, W. T. Water-Works Contractor, Charlotte, N. C.	1896
McCue, W. F. Care The Colorado Fuel and Iron Co., Boston Building, Denver, Col.	1897
McDermot, L. C. Supt. Water Department, 26 South Walnut St., East Orange, N. J.	1903
McDonald, Emmett Supt. Water and Light Co., Lincoln, Ill.	1904
McGrath, Robert H. Water-Works Trustees, LaFayette, Ind.	1904
McGilvray, Thomas T. Civil and Hydraulic Engr., Duluth, Minn.	1903
McKim, Robert Albert Asst. Engr. New Croton Aqueduct, 34 W. 91st St., New York, N. Y.	1902
McLeod, T. T. Mgr. Water Co., Missoula, Mont.	1904
McNamee, T. W. Supt. Water Company, Wabash, Ind.	1903
McWilliams, C. Q. Pres. Roaring Creek Water Co., P. O. Box, 85, Shamokin, Pa.	1901
Maignen, P. A. Water Engr., 1310 Arch St., Philadelphia, Pa.	1900
Manley, Samuel C. Pres. and Genl. Mgr. Maine Water Co., Augusta, Me.	1903
Manville, F. D. Local Mgr. Newport News Light & Water Co., Newport News, Va.	1901
Marion, J. A. Civil and Mechanical Engr., Montreal, Can.	1894

	Date of Membership.
Martin, H. P. Supt. Water-Works, Owensboro, Ky	1888
Mason, W. P. Prof. Chemistry, Rensselaer Poly. Institute, Troy, N. Y.	1892
Mather, Edmund Pres. Water Board, Harrisburg, Pa	1891
Maury, Dabney H. Consulting Engr. Peoria Water-Works Co., 129 North Jefferson Ave., Peoria, Ill	1894
Mead, Daniel W. Con. Engr., First National Bank Building, Chicago, Ill.	1889
Mellon, T. A. Pres. Kensington Water Co., 514 Smithfield St., Pittsburg, Pa	1903
Metcalf, Leonard Con. Civil Engr., 14 Beacon St., Boston, Mass	1903
Meyers, A. H. Supt. Water Co., Columbia, Pa	1903
Michie, John C. Civil Engr., Supt. Water Co., Durham, N. C	1903
Miller, Col. A. M.* U. S. Army, in charge of Washington Aqueduct and Filtration Plant, 2728 Pennsylvania Ave., Washington, D. C	1901
Miller, J. A. Supt. Water Co., Louisiana, Mo	1904
Miller, Joseph Torrence Sec. and Treas. Pennsylvania Water Co., 424 Maple Ave., Edgewood, Pittsburg, Pa	1903
Milligan, R. E. Chemist, 15 Broad St., New York, N. Y	1902
Milne, Alexander Supt. Water-Works, St. Catharines, Ontario, Can	1903
Milner, W. J. Birmingham, Ala	1884
Milton, Richard H. Supt. Water-Works, Reidsville, N. C	1902
Molis, Wm. Supt, Water-Works, Muscatine, Iowa	1882

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*Deceased.

	Date of Membership.
Monjeau, C. Hydraulic Engr., Middletown, Ohio	1889
Moth, R. H. City Engr. and Supt. Water-Works, Kenosha, Wis.	1901
Myers, Geo. M. Pres. Water & Light Co., Kansas City, Mo.	1902
Nettleton, Charles H. Agent Birmingham Water Co., Derby, Conn.	1888
Neubling, Emil L. Supt. and Engr. Water Dept., Reading, Pa.	1895
Neville, Thomas J. Water Department, Rochester, N. Y.	1888
Newton, Howard D. Pres. Water-Works Co., 175 Broad St., Norwich, N. Y.	1903
Nourse, H. O. Supt. Bureau of Water, Chicago, Ill.	1903
Ohliger, L. B. Supt. Water-Works, Canton, Ohio	1899
O'Shaughnessy, Jerry Supt. Department of Water, Columbus, Ohio	1897
Parkin, R. R. Supt. Water-Works, Elgin, Ill.	1890
Paterson, Arthur C. Supt. Water-Works, Everett, Wash.	1901
Patton, W. A. Pres. and Mgr. Catlettsburg, Kenora & Ceredo Water Co., Catlettsburg, Ky.	1904
Peene, Edward L. Supt. Water-Works, Yonkers, N. Y.	1901
Penney, C. L. Supt. Water-Works, Lorain, Ohio	1902
Perry, William Hydraulic Engr., 962 Craig St., Montreal, Canada	*1886-1903
Prenter, Martin Sec. and Genl. Mgr. Monongahela Water Co., 1113 Carson St., Pittsburg, Pa.	1903
Prentice, Allen T. Mechanical Engr., 499 N. State St., Chicago, Ill.	1890
Pitt, B. R. Pres. Water-Works Company, Pensacola, Fla.	1896

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*Resigned and re-elected.

	Date of Membership.
Poetsch, Charles J. City Engr. and Pres. Board of Public Works, Milwaukee, Wis.	1903
Pollard, W. D. Engr. Water-Works, Pottsville, Pa.	1892
Powers, J. B. Trustee and Sec. Board of Water-Works Trustees, 312 Security Bldg., Dubuque, Iowa	1903
Priddy, Chas. N. Sec. and Supt. Water-Works, Leadville, Col.	1886
Purdy, J. H. Supt. American Water-Works and Guarantee Company, P. O. Box 1103, Pittsburg, Pa.	1896
Quick, Alfred Merritt Water Engr., Baltimore, Md.	1901
Randolph, W. C. N., Jr. Supt. Water-Works, Lynchburg, Va.	1902
Rapp, W. M. Supt. Construction Water Department, Atlanta, Ga.	1899
Reed, Wilbur F. Supt. Water-Works, Kalamazoo, Mich,	1901
Reyer, Geo. 1004 College St., Nashville, Tenn.	1884
Riley, Lee Chief Engr. Metropolitan Water Co., Kansas City, Kan.	1897
Roberts, R. O. Wynne Water Engr., Cape Town, S. Africa	1903
Robertson, Geo. H. Supt. Water-Works, Yarmouth, N. S.	1888
Robertson, Wm. F. Supt. Clarendon Water Co., Wilmington, N. C.	1903
Robinson, Wm. P. Mgr. Denver Union Water Co., Denver, Col.	1897
Robinson, Sidney C. Mgr. Water-Works, Walkerville, Ontario, Can.	1904
Rolfe, W. E. Engr. of Distribution Water Dept., 3855 Flad Ave., St. Louis, Mo.	1904
Rosamond, S. J. Supt. Municipal Water-Works Company, Fort Smith, Ark	1898

		Date of Membership.
Rowe, Charles E.	Supt. Dept. of Water, Dayton, Ohio	1901
Russell, S. Bent	Con. Engr., 417 Pine St., St. Louis, Mo	1888
Russell, W. S.	Dickson, N. D	1895
Rust, C. H.	City Engr. and Mgr. Water-Works, Toronto, Canada	1903
Ruthrauff, Harry	Water and Plumbing Inspector, Decatur, Ill	*1898-1903
Ryder, Philip F.	Vice-Pres. and Treas. Water-Works Trustees, Dubuque, Iowa	1903
Ryle, William	Paterson, N. J	1884
Salmon, C. B.	Owner Water-Works, Beloit, Wis	1902
Sawyer, J. T.	Pres. Water-Works Co., Waverly, N. Y	1885
Scott, William G.	City Treas. and Mgr. Financial Dept. Water-Works, Winnipeg, Manitoba, Canada	1903
Shepherd, A. B.	Supt. of Water Supply and Distribution, Pittsburg, Pa.	1896
Sheppard, James H.	Supt. City Water Co., Monongahela, Pa	1903
Shepperd, F. W.	Fire and Water Engineering, Bennett Bldg., New York, N. Y	1888
Sherrerd, Morris R.	Engr. and Supt. Dept. of Water, 128 Halsey St., Newark, N. J	1897
Shields, W. S.	Con. Engr., 1715 Marquette Building, Chicago, Ill	1899
Sidelinger, Geo. B.	Supt. Water-Works, Danville, Ill	1902
Simin, Nicholas P.	Con. Engr., 3 Razgulay, Moscow, Russia	1898
Simpson, Lawrence	Sec. Water Company, Memphis, Tenn	1898

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*Resigned and re-elected.

	Date of Membership.
Slocum, Charles Egbert Supt. Belleville Deep Well Water Co., Belleville, Ill.	1902
Smith, Anthony P. Mechanical Engr., Newark, N. J.	1890
Smith, Erastus G. Ph. D., Professor Chemistry, Beloit, Wis.	1890
Smith, H. L. Supt. Water Department, Norfolk, Va.	1903
Smith, J. Waldo Chief Engr. Croton Aqueduct, 213 Stewart Building, New York, N. Y.	1898
Smith, Owen T. Supt. Water-Works, Freeport, Ill.	1893
Soper, Geo. A. Ph. D., Engr. and Chemist, 29 Broadway, New York, N. Y.	1900
Snow, F. H. Con. Engr., Tremont Bldg., Boston, Mass.	1899
Snow, Archie H. Supt. Water Company, Montclair, N. J.	1898
Spalding, E. B. Supt. Water-Works, Sioux City, Iowa	1899
Sprenkel, John F. Genl. Mgr. York Water Co., York, Pa.	1901
Sterling, Joe. C. Supt. Water-Works, Monroe, Mich.	1903
Stillwell, H. C.* 50 Cass St., Providence, R. I.	1896
Strasser, J. M. Supt. Electric Light & Power Co., LaGrange, Ill.	1896
Strause, Nathan Pres. Water-Works, Ashland, Ohio	1904
Sullivan, Eugene Water Commissioner, Boston, Mass.	1903
Sullivan, M. F. Supt. Water-Works, Mobile, Ala.	1901
Talbot, Arthur N. Professor of Municipal and Sanitary Engineering, University of Illinois, Urbana, Ill.	1894

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*Deceased.

	Date of Membership.
Talbott, Frank Supt., Sec. and Treas. Water-Works, Danville, Va.	1904
Taylor, Samuel A. Con. and Constructing Engr., 339 Fifth Ave., Pittsburg, Pa.	1902
Thomas, C. O. Pres. Water Co., Caro, Mich.	1903
Thomas, Robt. J. Supt. Water-Works, Lowell, Mass.	1900
Tighe, James L. City Engr., Holyoke, Mass.	1901
Tilden, Jas. A. Mechanical Engr., Hersey Mfg. Co., Boston, Mass.	1889
Toal, D. C. Editor "Water and Gas Review," 35 Warren St., New York, N. Y.	1903
Todd, William Supt. Electric Light & Water-Works, Austin, Minn.	1901
Tomlinson, Samuel Department Ex-Engineer Water-Works, Municipal Engineer, Singapore, S. S.	1887
Torrance, Kenneth Chief Engineer Pumping Station, Logan St. and Atlantic Ave., Brooklyn, N. Y.	1897
Trautwine, Jno. C., Jr. Civil Engineer, 257 South Fourth St., Philadelphia, Pa.	1896
Travis, Isaac N. Supt. Water-Works, Orange, N. J.	1898
Tubbs, J. Nelson Con. Engr., 405 Wilder Bldg., Rochester, N. Y.	1886
Tucker, A. A. Supt. Mains, Water Dept., Memphis, Tenn.	1892
Veach, W. A. Receiver Water-Works Company, Newark, Ohio	1896
Verner, T. H. Supt. Water and Light Dept., McKeesport, Pa.	1903
Volkhardt, William Supt. Crystal Water Co., Stapleton, N. Y.	1902
Wall, E. E. Asst. Engr. Water Dept., 4220 McPherson St., St. Louis, Mo.	1904

		Date of Membership.
Wanner, P. D.	Pres. Newport Home Water Co., Reading, Pa.	1891
Warde, John S.	Supt. and Engr. Staten Island Water Supply Company, West New Brighton, N. Y.	1892
Watkins, Thomas	Mechanical Engr., Johnstown, Pa.	1892
Watson, Walter L.	Supt. Clear Spring Water Co., Catasaqua, Pa.	1901
Watts, W. H.	Supt. Water-Works, El Paso, Tex.	1888
Way, J. F.	Supt. Water, Light & Power Co., Watertown, S. Dak.	1904
Wheeler, Sam.	Supt. Water Co., Ashland, Wis.	1903
Wheeler, Genl. Elbert	Treas. Knoxville, Tenn., Water Co., 14 Beacon St., Boston, Mass.	1903
Wegman, Edward	Care Aqueduct Commission, 70 Fisher Ave., White Plains, N. Y.	1902
Wehr, Albert H.	Sec. and Treas. Baltimore County Water & Electric Company, Baltimore, Md.	1901
Weston, Robert Spurr	Chemist and Bacteriologist, 14 Beacon St., Boston, Mass.	1898
Whipple, George C.	Con. Engr., 220 Broadway, New York, N. Y.	1904
Whitney, Dr. Geo. F.	Biologist, 44 Central Ave., East Orange, N. J.	1904
Wiles, C. W.	Supt., Sec. and Treas., Water-Works, Delaware, Ohio.	1899
Wilkinson, J. H.	Supt. Water-Works, Bowling Green, Ky.	1889
Williams, Howard L.	Supt. Water-Works, Luddington, Mich.	*1894-1903
Wills, E. S.	Supt. Water Company, Atchison, Kan.	1885

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*Resigned and re-elected.

	Date of Membership.
Wing, Abram	
Supt. Water-Works Company, Adrian, Mich.	1896
Wirt, R. D.	
219 North Third St., Philadelphia, Pa.	1885
Wood, Jas. W.	
Pres. Henderson Water Company, Henderson, N. C., care Tippett & Wood, Phillipsburg, N. J.	1896
Wood, John H.	
Sec. and Supt. Water-Works, Baton Rouge, La.	1893
Woodburn, Wm. F.	
Director Water Co., care R. D. Wood & Co., 400 Chestnut St., Philadelphia, Pa.	1903
Woodruff, Timothy	
Supt. Water-Works, Bridgeton, N. J.	1888
Woodward, Park	
Genl. Mgr. Water-Works, Atlanta, Ga.	1896
Worrell, M. L.	
Supt. Water Company, Selma, Ala.	1903
Wright, Millard F.	
Supt. Water-Works, Butler, Pa.	1890
Young, Ezra P.	
Pres. Water Company, Edgworth, Pa.	1902

ASSOCIATE.

Adams, Lydon E.	
Genl. Sales Mgr. Garlock Packing Co., 5224 Parkside, Philadelphia, Pa.	1904
American Asphaltum and Rubber Co.	
Woman's Temple, Chicago, Ill.	1903
American Pipe Manufacturing Co., The	
112 North Broad St., Philadelphia, Pa.	1903
American Steel and Wire Co.	
The Rookery, Chicago, Ill.	1903
American Valve and Meter Co.	
324 Pike Bldg., Cincinnati, Ohio.	1900
Babcock & Wilcox Boiler Co.	
85 Liberty St., New York, N. Y.	1896
Barr Pumping Engine Co.	
Philadelphia, Pa.	1903

		Date of Membership.
Bingham & Taylor	Church and Jackson Sts., Buffalo, N. Y.	1882
Bourbon Brass & Copper Works.	202 E. Front St., Cincinnati, Ohio	1889
Builders' Iron Foundry	Providence, R. I.	1901
Campbell, J. B., Brass Works	Brass and Iron Goods for Water-Works, Erie, Pa.	1901
Central Foundry Co.	116 Nassau St., New York, N. Y.	1903
Chapman Valve Manufacturing Company	Indian Orchard, Mass.	1884
Chicago Bridge and Iron Company	Builders of Water Towers and Standpipes, 105th and Throop Sts., Chicago, Ill.	1898
Clow, J. B. & Sons	Lake and Franklin Sts., Chicago, Ill.	1885
Colorado Fuel and Iron Company	Denver, Col.	1897
Columbus Board of Public Service	Water Dept., Columbus, Ohio	1887
Cook Well Company	15 S. Fourth St., St. Louis, Mo.	1894
Corbett, M. A.	Sec. and Mgr. The Columbus Meter Seal Mfg. Co., Columbus, Ohio	1904
Day, Charles R.	Sales Agent The Midvale Steel Co., 100 Broadway, New York, N. Y.	... 1904
Dayton Board of Public Service	Water Dept., Dayton, Ohio	1892
Detroit Chemical Works	Detroit, Mich.	1903
Dresser, S. R.	Mfgr. Pipe Couplings and Sleeves, Bradford, Pa.	1904
Drummond, M. J. & Co.	Cast Iron Pipe, 182 Broadway, New York, N. Y.	1895
Dunn Manufacturing Co.	1517 Farmers' Bank Bldg., Pittsburg, Pa.	1903
Eddy Valve Manufacturing Co.	Waterford, N. Y.	1886

	Date of Membership.
Eley, Philip Machine Water Appliances, Bayonne, N. J.	*1892-1901
D. L. Ellis City Engineer, Great Falls, Mont	1904
Farnan Brass Works 23 Centre St., Cleveland, Ohio	1892
Gamewell Fire Alarm Telegraph Co., The 19 Barclay St., New York, N. Y	1903
General Chemical Co. Manufacturers of Filter Alum and Dealers in Sulphur, 135 Adams St., Chicago, Ill	1902
Gillespie, T. A. Pres. The T. A. Gillespie Co., Orange, N. J	1904
Glauber Brass Mfg. Co. 1643-1677 Superior St., Cleveland, Ohio	1904
Great Falls, Montana, Water Department Great Falls, Mont	1904
Hays Manufacturing Company Erie, Pa	1882
Hersey Manufacturing Company South Boston, Mass	1887
Hoge & Swift Manufacturers' Agents, Portland, Oregon	1904
Illinois Malleable Iron Company 30 W. Monroe St., Chicago, Ill	1890
International Steam Pump Co. Water-Works Machinery, 114 Liberty St., New York, N. Y	1901
Jackson Filter Mfg. Co. Chemical Building, St. Louis, Mo	1904
Kellogg, E. H. & Co. 243 South St., New York, N. Y	1886
Kennedy, Daniel Pres. Kennedy Valve Manufacturing Company, 57 Beekman St., New York, N. Y	1895
Lead Lined Iron Pipe Co., The Wakefield, Mass.	1898
Lennox Machine Company Water Tapping Machine, Marshalltown, Iowa	1896

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*Resigned and re-elected.

	Date of Membership.
London Water Board London, Canada	1892
Ludlow Valve Manufacturing Company Troy, N. Y.	1882
Mueller, H., Manufacturing Company Decatur, Ill.	1882
National Brass & Metal Co. 256 S. Third St., Minneapolis, Minn.	1904
National Meter Company 84-86 Chambers St., New York, N. Y.	1882
Neptune Meter Company 142 Market St., Newark, N. J.	1894
New York Continental Jewell Filtration Co. 15 Broad St., New York, N. Y.	1888
Norfolk Water-Works Norfolk, Va.	1889
Pennsylvania Salt Manufacturing Co., The 115 Chestnut St., Philadelphia, Pa.	1903
President Board of Public Works Grand Rapids, Mich.	1895
Pleuger & Henger Manufacturing Company St. Louis, Mo.	1896
Pittsburg Meter Company East Pittsburg, Pa.	1898
Rensselaer Manufacturing Company Troy, N. Y.	1890
Ross Valve Co. Oakwood Ave., Troy, N. Y.	1891
Ryerson & Son, Jos. T. Iron and Steel Merchants and Special Agents, 18 Milwaukee Ave., Chicago, Ill.	1902
Stilwell-Bierce & Smith-Vaile Co., The Pumping Engines, Dayton, Ohio	1901
Smith, Anthony P., Manufacturing Company Newark, N. J.	1897
Sweet & Doyle Manufacturers Water Valves, Cohoes, N. Y.	1900
Thomson Meter Company 79 Washington St., Brooklyn, N. Y.	1891
Tod, The William Co., High Duty Pumping Engines, Youngstown, Ohio	1904

	Date of Membership.
Trenton Water Works Trenton, N. J.	1898
Union Water Meter Company Worcester, Mass.	1882
United States Cast Iron Pipe and Foundry Company 217 La Salle St., Chicago, Ill.	1902
Walworth Manufacturing Company 132 Federal St., Boston, Mass.	1891
Westinghouse Machine Co., The East Pittsburg, Pa.	1904
Whitall, W. vanR. Pres. Hydro-Carbon Co., Denver, Colo.	1904
Wood, R. D. & Co 400 Chestnut St., Philadelphia, Pa.	1884
Yeiser, L. B. Salesman for The Sanitary Co., Cleveland, Ohio	1904

LIST OF MEMBERS ARRANGED GEOGRAPHICALLY.

ALABAMA, Total Membership, 4.

HONORARY—Cameron, W. L.

ACTIVE—Milner, W. J.; Sullivan, M. F.; Worrell, M. L.

ARKANSAS, Total Membership, 1.

ACTIVE—Rosamond, S. J.

CALIFORNIA, Total Membership, 3.

ACTIVE—Booker, Geo. E.; Hall, J. W.; Le Conte, L. J.

COLORADO, Total Membership, 8.

ACTIVE—Case, E. W.; Dunbaugh, Geo. J.; Hopkins, Jas. A.; McCue, W. F.; Priddy, C. N.; Robinson, Wm. P.

ASSOCIATE—Whitall, W. Van R.; Colorado Fuel and Iron Co.

CONNECTICUT, Total Membership, 2.

ACTIVE—Brooks, Isaac W.; Nettleton, Chas. H.

DELAWARE, Total Membership, 3.

ACTIVE—Bond, Jos. A.; Haton, T. Chalkley; Leisen, Theodore Alfred.

DISTRICT OF COLUMBIA, Total Membership, 1.

ACTIVE—Miller, Col. A. M.

FLORIDA, Total Membership, 2.

ACTIVE—Ellis, Robt. N.; Pitt, B. R.

GEORGIA, Total Membership, 3.

ACTIVE—Clayton, R. M.; Rapp, W. M.; Woodward, Park.

ILLINOIS, Total Membership, 44.

HONORARY—Foster, J. F.

ACTIVE—Alvord, John W.; Amsbary, F. C.; Artingstall, Samuel G.; Ashley, Burton J.; Bancroft, P. T.; Clark, H. W.; Cobb, C. H.; Cole, John A.; Ericson, John; Gannon, Thos. W.; Guilford, Andrew J.; Hardy, A. W.; Henderson, C. R.; Horton, Horace E.; Huggins, D. E.; Jefferis, Louis M.; Keeler, H. E.; Kemp, Jno. E.; Lautz, Henry; Lucas, Fred L.; McCorkindale, Wm. J.; McDonald, Emmett; Maury, Dabney H.; Mead, Daniel W.; Nourse, H. O.; Parkin, R. R.; Prentice, Allen T.; Ruthrauff, Harry; Shields, W. S.; Sidelinger, Geo. B.; Slocum, Chas Egbert; Smith, Owen T.; Strasser, J. M.; Talbott, Arthur N.

ASSOCIATE—American Asphaltum & Rubber Co.; American Steel & Wire Co.; Chicago Bridge & Iron Co.; Clow, J. B. & Sons; General Chemical Co.; Illinois Malleable Iron Co.; Mueller, H., Mfg. Co.; Ryerson & Son, Jos. T.; United States Cast Iron Pipe & Foundry Co.

INDIANA, Total Membership, 8.

ACTIVE—Davis, F. A. W.; Dill, H. A.; Ford, Edwin H.; Gwinn, Dow R.; Heeger, Emil; Hulley, Elkanah; McGrath, Robt. H.; McNamee, T. W.;

IOWA, Total Membership, 18.

ACTIVE—Barker, W. H.; Berry, J. P.; Chatham, J.; Donahue, J. P.; Ellwanger, John; Fitch, W. P.; Fox, Chas. J.; Hart, Ed. W.; Healey, G. B.; Hooper, Thos. N.; Kastberg, Karl C.; Lovell, Walter D.; McArthur, Arthur; Molis, William; Powers, J. B.; Ryder, Philip F.; Spaulding, E. B.

ASSOCIATE—Lennox Machine Co.

KANSAS, Total Membership, 5.

ACTIVE—Bishop, John L.; Chisham, J. M.; Hood, Chas.; Riley, Lee; Wills, E. S.

KENTUCKY, Total Membership, 9.

ACTIVE—Burnett, M.; Charles, S. A.; Glazier, W. L.; Glore, W. H.; Hermany, Charles; Hornung, George; Martin, H. P.; Patton, W. A.; Wilkinson, J. H.

LOUISIANA, Total Membership, 2.

ACTIVE—Gardner, L. H.; Wood, John H.

MAINE, Total Membership, 3.

ACTIVE—Eaton, Harvey D.; Getchell, W. B.; Manley, Samuel C.

MARYLAND, Total Membership, 3.

ACTIVE—Harlow, Jas. H.; Quick, Alfred Merritt; Wehr, Albert H.

MASSACHUSETTS, Total Membership, 18.

ACTIVE—Cook, Henry A.; Ellsworth, Emory A.; Glover, Albert S.; Kimball, Frank C.; Locke, J. W.; Metcalf, Leonard; Snow, F. H.; Sullivan, Eugene; Thomas, Robt. J.; Tighe, Jas. L.; Tilden, Jas. A.; Wheeler, General Elbert; Weston, Robert Spurr.

ASSOCIATE—Chapman Valve Mfg. Co.; Hersey Mfg. Co.; Lead Lined Iron Pipe Co.; Union Water Meter Co.; Walworth Mfg. Co.

MICHIGAN, Total Membership, 20.

ACTIVE—Anderson, L. W.; Cahill, Stephen; Campbell, Jas. J.; Carroll, Daniel W.; Croll, Emil A.; Devine, P. H.; Dunbar, E. L.; Gould, Uriah; Hale, A. K.; Holmes, Alba L.; Houston, George; Hubbell, Clarence W.; Hutzell, Titus F.; Reed, Wilbur F.; Sterling, Joe C.; Thomas, C. O.; Williams, Howard L.; Wing, Abram.

ASSOCIATE—Detroit Chemical Works; President Board of Public Works, Grand Rapids, Mich.

MINNESOTA, Total Membership, 10.

HONORARY—Bement, R. B. C.

ACTIVE—Cappelen, F. W.; Case, L. N.; Caulfield, John; Connor, F. J.; Fanning, J. T.; McConnell, J. H.; McGilvray, Thos. T.; Todd, William.

ASSOCIATE—National Brass & Metal Co.

MISSISSIPPI, Total Membership, 1.

ACTIVE—Lorenz, John.

MISSOURI, Total Membership, 19.

HONORARY—Holman, M. L.; Watts, Sylvester.

ACTIVE—Adkins, B. C.; Anderson, J. F.; Andrews, Louis P.; Barron, A. M.; Binder, Frederick C.; Brown, L. O.; Goodwin, Wm. G.; Hibbeler, H. D.; Lefavor, Walter L.; Miller, J. A.; Myers, Geo. M.; Rolfe, W. E.; Russell, S. Bent; Wall, E. E.

ASSOCIATE—Cook Well Co.; Jackson Filter Mfg. Co.; Pleuger & Henger Mfg. Co.

MONTANA, Total Membership, 3.

ACTIVE—Carroll, Eugene; McLeod, T. T.

ASSOCIATE—Great Falls Water Dept.

NEBRASKA, Total Membership, 4.

ACTIVE—Carlson, J. A.; Deffenbaugh, J. M.; Fairfield, E. M.; Koenig, Arnold C.

NEW JERSEY, Total Membership, 25.

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Garrison, Ralph H.; Gedney, Jerome D.; Griffin, J. William; Jones, A. J.; Kellogg, R. M.; McDermitt, L. C.; Ryle, Wm.; Sherrerd, M. R.; Smith, Anthony P.; Snow, Archie H.; Travis, Isaac N.; Whitney, Dr. Geo. F.; Wood, Jas. W.; Woodruff, Timothy.

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NEW MEXICO, Total Membership, 2.

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NEW YORK, Total Membership, 81.

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NORTH DAKOTA, Total Membership, 1.

ACTIVE—Russell, W. S.

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ACTIVE—Hawks, W. E.

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ASSOCIATE—Norfolk Water Works.

WASHINGTON, Total Membership, 1.

ACTIVE—Paterson, Arthur C.

WISCONSIN, Total Membership, 9.

ACTIVE—Benzenberg, G. H.; Ellison, B. F.; Heim, J. B.; Laing, H. H.; Moth, R. H.; Poetsch, Chas. G.; Salmon, C. B.; Smith, Erastus G.; Wheeler, Sam.

WYOMING, Total Membership, 1.

ACTIVE—Emery, Ezra L.

CANADA, Total Membership, 12.

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ASSOCIATE—London Water Board.

FOREIGN COUNTRIES, Total Membership, 5.

HONORARY—Nakijima, Y., Tokio, Japan.

ACTIVE—Humphreys, William H., York, England; Roberts, R. O. Wynne, Cape Town, South Africa; Simin, Nicholas P., Moscow, Russia; Tomlinson, Samuel, Singapore, S. S.

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